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Introduction

ORIGINAL

VOLUME I
BOOK 1

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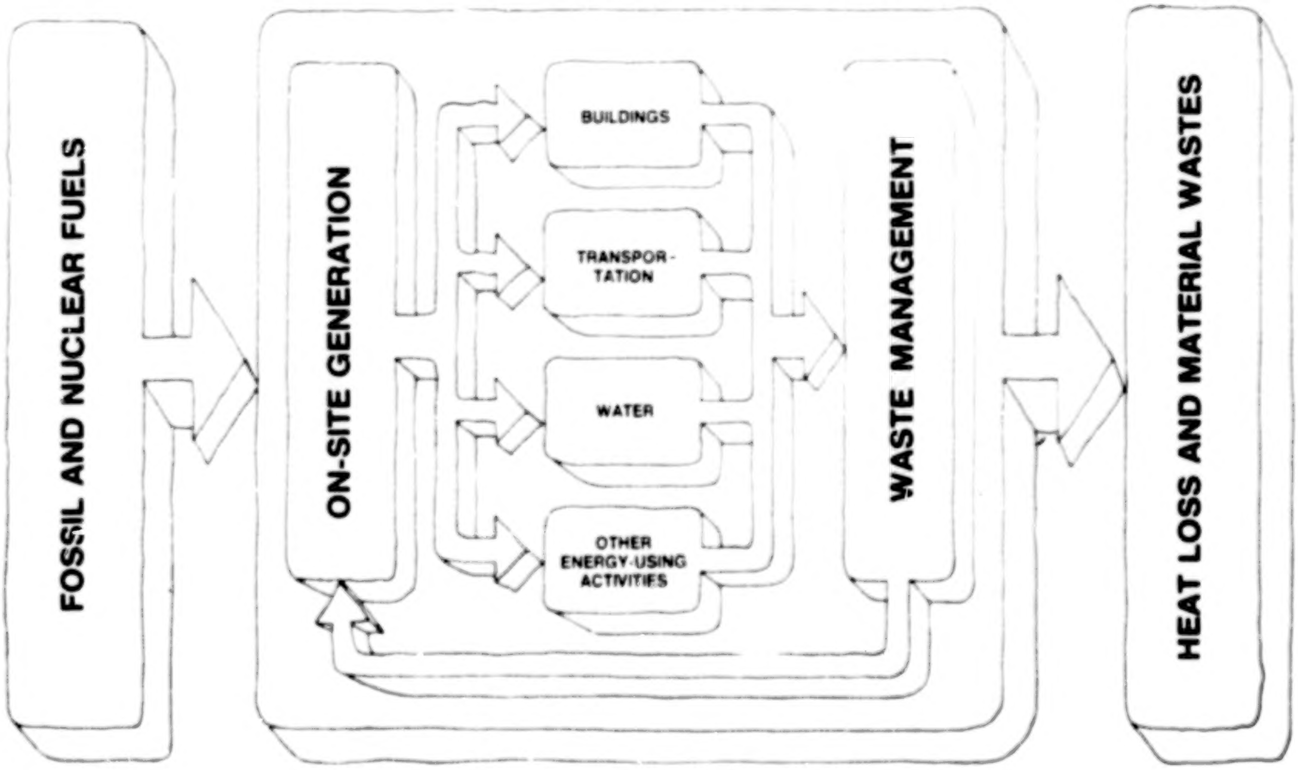
SITE ENERGY-USING FUNCTIONS



This introductory section is part of a two volume Planning Guide designed to help you formulate a site-specific Energy Conservation Management Plan. It provides you with background information about energy and energy conservation; an overview of the contents of the Planning Guide; and instructions for actually making an overall Plan.

ACKNOWLEDGEMENT

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FOREWORD

The Energy Management Planning Guide is a two volume set of materials designed to aid site managers and other employees of the Fish and Wildlife Service in putting together a basic energy saving program for their sites.

Volume I is divided into six separately bound sections entitled:

I-1 Introduction
I-2 Buildings
I-3 Transportation
I-4 Waste Management
I-5 Water Conservation
I-6 Environmental Awareness Program

Volume II contains only one extensive section entitled: On-Site Generation.

Each section may be removed from the binder and worked on separately. However, the final goal of this guide is an integrated plan, called the Energy Conservation Management Plan, for making refuges and hatcheries more energy efficient in every aspect of their operation. Presented in the text of each section are detailed instructions, along with the technical information needed, for carrying out a step-by-step planning process resulting in the formulation of the comprehensive plan.

Also provided at the end of each section are bibliographies of related materials to supplement the basic information provided in the Guide. References to these materials, designated with a number in parenthesis (e.g., (1)), are often included in the text and are also listed at the end of each section.

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INTRODUCTION

ENERGY

"Energy is the go of things," said physicist G. Clark Maxwell. Everything physical in our universe is energy -- energy bound in complex patterns called matter, energy randomly dispersed, or energy flowing through systems. Energy is also defined as the capacity to do work, and it is in this functional aspect that we recognize it most easily. We use energy in the form of fuels and power to perform tasks for us.

Energy is an increasingly important consideration in the operations of the U.S. Fish and Wildlife Service (FWS). During the last half-dozen years, the price of energy has increased at a tremendous rate, much faster than increases in the FWS budget. As a result, we are spending an ever larger portion of our budget on energy rather than on items which contribute more directly to our primary missions.

Some FWS stations have been able to lessen the impact of energy price increases by instituting extremely effective energy conservation programs, with energy use reductions of up to 50% in some cases. While this rate of reduction may not be possible for every FWS refuge, hatchery or laboratory, an effective energy conservation program is essential at every FWS station.

The purpose of this manual is to guide you through the process of developing your particular site's energy conservation program. FWS' goal is to reduce its energy use to the minimum level that is cost effective and at the same time to promote conservation among our visitors by demonstrating workable and successful conservation measures.

WHOLE SYSTEMS

The best preparation for planning an energy management program is to understand the need for a systems approach to conservation. Systems are sets of interrelated parts which interact to perform a desired function. To solve our energy problems, we need to look carefully at each part of the system, and we need to see each part as an element of the larger system. Each site within the Fish and Wildlife Service can be seen as an energy system that draws on external sources of energy for its support. There are great differences between sites in the amounts of energy available from natural sources, amounts of fuel and human energy consumed for maintenance, and potential for increased energy efficiency. The energy efficiency of each unit of the national system of fish hatcheries and wildlife refuges helps determine the efficiency of the entire system.

A MODEL CONSERVATION STRATEGY

The use of energy can be viewed easily within a simple model for energy use and transfer. First, there is a demand or a need for the performance of a desired function. To provide this function, there is an energy-using system or component of a system. An energy input is required to make the system work. As the desired function is provided, a certain portion of the energy input is rejected as waste -- energy not used in the process. This waste is inevitable whenever there is a transfer of energy. Figure 1 illustrates the energy model.

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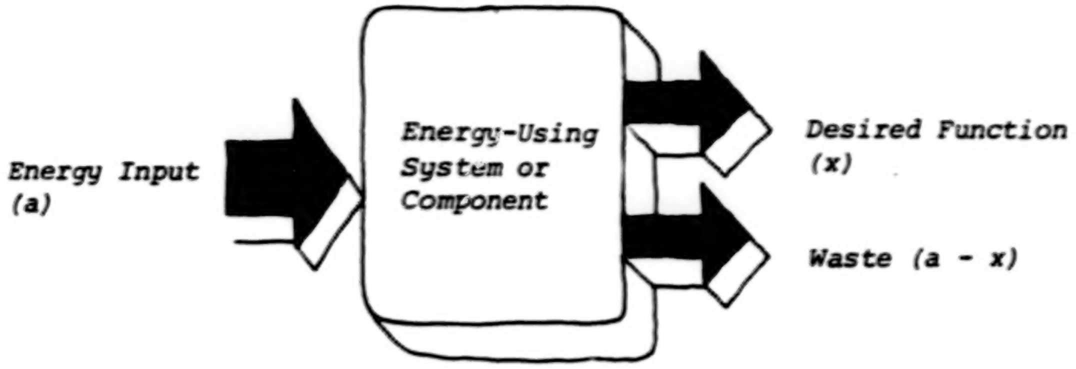

Figure 1 *Energy Use and Transfer*

Energy-Using Systems

Virtually all natural and manmade systems use energy in some form. Natural systems capture and convert energy from sunlight; manmade systems, such as buildings or transportation systems, depend on the energy inputs.

Energy Inputs

These are the energy sources used directly or indirectly in the energy-using system. They include natural gas, propane, gasoline, fuel oil (both No. 2 and No. 6), coal, wood, water, solid waste, solar, wind, and hydroelectric energy. Some of these inputs are supplied commercially and paid for as a part of a site's energy budget. But it should not be forgotten that "free" energy often comes indirectly from the sun, the wind and heat from human bodies.

Desired Functions

Energy inputs are processed by systems and the components of systems to provide for desired functions. Taking a building as an example of an energy-using system, such desired functions include heating of domestic hot water, space heating and cooling, ventilation, lighting, and cooking.

Waste

Just as dirt is matter out of place that can't be used, so waste energy is energy out of place that can't be put to useful work. Since perfectly efficient conversion is theoretically impossible, there is always some waste in any transfer process. This occurs in the form of heat, water, and solids. However, what is waste in some circumstances is useful work in others. For example, heat given off by incandescent lighting systems may be waste during the summer months, when air conditioning is required for space cooling. During the winter, by contrast, the heat from the same lights can help to warm space, and slightly reduce heating loads.

Efficiency-Evaluation

You must always put into a system more energy than you can get out as useful work. This difference between energy input and useful work output is called the efficiency of a system.

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Efficiency can be evaluated by looking at the ratio of the energy that goes towards providing the desired function (x) and the energy input (a). If (a) in our model is 100 gallons of fuel oil and the heat from only 40 gallons provides the desired function (x), then the heat from 60 gallons is waste and the system is 40% efficient. To improve efficiency, the percentage of energy input that is used to perform a desired function must be increased. This can be done by increasing the efficiency of the system or component (e.g. reducing required fuel oil to 40 gallons in the above example), and by capturing waste energy for use as an energy input to the system.

BENEFITS FROM CONSERVATION

Adoption of sound, well-conceived energy management programs provides many benefits. Some benefits are easy to recognize, because they are quantifiable (figured in numbers) and can be added up at the end of the month or year. An overall savings of 20% in annual gasoline consumption or a reduction in the fuel oil bill of $400 in a quarter are examples of quantified benefits that can be directly related to a program of energy-saving measures. Other benefits are less apparent since they cannot be quantified and will never appear on the balance sheet. Programs to inform the public about the need to save energy and conserve scarce resources are important, but often cannot be evaluated in terms of Btu or dollars saved.

The benefits of conservation may also be distributed unevenly among affected groups. When an aggressive program is launched, the benefits may spread considerably beyond those who undertake the first set of measures or those who initially invest in conservation. As a broad example, the country as a whole benefits when energy consumption becomes more efficient; because less money flows out to foreign countries, demand is reduced on remaining domestic fuel supplies, and more time to convert existing energy systems from nonrenewable to renewable energy inputs is gained.

The same considerations apply at FWS sites. There are strong reasons to undertake measures that will result in direct reductions in the annual budget for energy, so that energy expenses will not inflate so fast and so that energy use may be controlled in line with Departmental program goals. There are also good reasons to undertake measures that do not yield a direct impact on the site energy budget, but which nonetheless save energy for other individuals or groups. For example, energy consumption by the visiting public is an especially important area. Planning for people-movers or other mass transit systems to operate within the boundaries of a refuge may have no impact on the energy budget of the refuge, or might even cause an increase in the refuge's annual budget. However, it may also result in a considerable non-budgetary savings in energy use by visitors, because fewer vehicles will be used to tour the refuge. Additional benefits may come in the form of reduced air pollution.

IDENTIFYING BENEFITS

Identifying the expected benefits from conservation measures is a key step in establishing any program for energy conservation/management. Benefits are available at points where the system is wasting energy right now. Once you locate the inefficiencies in a system or component, you need to estimate the actual dollars and cents

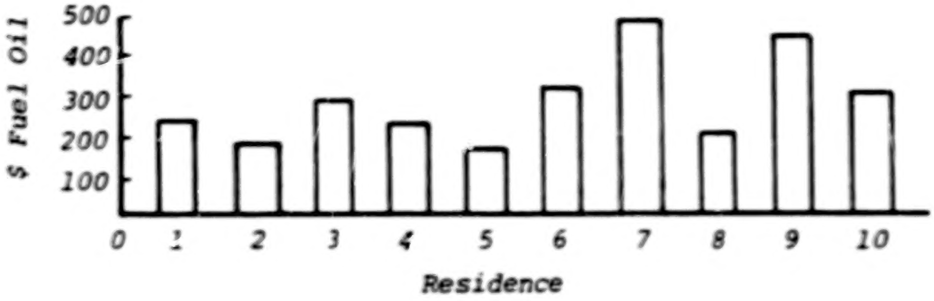

Figure 2 *Energy Use Converted to Fuel Dollars for Residences*

savings for each energy saving measure.

The following discussion concerns detection of waste and economic analysis.

Waste Detection

Energy waste is energy that isn't used to provide a desired function and that can't be captured for use as an energy input. Because we're well acquainted with our buildings and vehicles, we often don't readily recognize the waste involved in their use. Or, if we do, we've learned to live with it. But, if we continue with business as usual operations, we will fail to understand how we're losing energy and how great the waste is. This lack of knowledge seriously limits the ability to do anything to improve the situation.

Two basic methods are available for detecting and revealing waste -- the essential first step in planning an effective energy management program. Basic method number one is energy accounting; number two is a systems inventory and analysis of conservation measures.

Energy Accounting

Energy accounting links energy-using systems to energy consumption by monitoring consumption of nonrenewable fuels. The more closely you can measure nonrenewable fuel consumption, whether it is gasoline for generators or propane for cooking ranges, the better your conservation planning will be. Accounting shows you energy waste by relating specific energy use to a standard of efficient usage. With a data base, you can begin to understand how these relationships work.

For instance, from your data you could construct a bar chart of energy use in the buildings at your site that assigns fuel dollars to each residence. If you know how much No. 2 fuel oil each building uses, you can make comparisons among the buildings. The moment you start comparing, you are using a standard.

In Figure 2, if you assume that all the residences are the same size, you will notice that residences 7 and 9 appear to be using much more fuel than the others. A standard of comparison can also be used for vehicles. If nine of your mini-pickup trucks get between 30 and 37 mpg, and the tenth gets 21 mpg, then the tenth truck is probably wasting energy.

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This is what energy accounting does. It tells you where you stand by allowing you to compare your own rate of fuel usage with an average or with an efficiency standard. You will be given information in each Section of this manual which will help you to determine if your buildings, vehicles, etc., are above or below average efficiency standards.

Systems Inventory and Analysis of Measures

When we attempt to account for energy use, we need to understand the physical characteristics of the system we're trying to improve. This means making an inventory of the system, to identify its various working parts and how they might affect energy use. This inventory helps to narrow the focus to areas with the greatest potential for savings. Most energy using systems offer opportunities for efficiency improvements. These are frequently typical for a class of systems -- such as buildings -- and are called conservation measures. Comparing a list of typical conservation measures for buildings with one of the buildings you manage will reveal opportunities for savings. This is a physical method for detecting waste. It will raise questions like "Could we replace this water pump with a more efficient one?"; "Could we use more car-pooling to get the food service staff to and from work every day?"; or "Can we replace our electric hot water heaters with solar units?"

Combining Approaches

Used separately, either energy accounting or systems inventory and analysis is imperfect; used together they are exceptionally effective. You will work out your own methods for putting the approaches together, but one useful procedure is outlined below.

1. Account for energy use first, to target your inventory of energy-using systems.
2. Then, match conservation measures with the systems you suspect are wasteful.
3. Lastly, check your energy accounts.
    a. When you have computed energy savings for a conservation measure or set of measures, the total savings should seem reasonable. For instance, do the estimated savings add up to more than the current fuel use?
    b. When you have not been able to compute energy savings for a conservation measure or set of measures, check your consumption against a standard (either a national standard or an average of the consumption of your own stock for that particular energy-using system). If your consumption is high in relation to the standard, you should have the confidence to go ahead with the measure.

As you develop more experience at your site, you will be able to make each technique increasingly accurate. The first attempt at energy accounting is bound to be rough, but as you improve your data on fuel consumption, your energy accounting picture will tell you more. In fact, the beauty of energy accounting is that as you carry out your conservation program, you will start to see the energy savings from the conservation measures you've implemented. Your assessment of other potential conservation measures and the savings associated with them will also become more accurate.

Economic Analysis

The approaches presented above will show you where you *could* get improvements in efficiency, but they're not enough to tell you if you *should* make the improvements. To make this decision, you need to calculate the cost-effectiveness of measures.

Generally, a measure is considered cost-effective if the total amount of money saved during its entire life is greater than the total amount required to implement, install, operate, and maintain it over the same time period. A measure is *not* cost-effective if you must spend *more* than you will save during the entire time the measure is in effect.

The indicator of cost-effectiveness for energy conservation measures which best suits your needs is payback period. Simple payback period (SPP) is figured by dividing the first cost (purchase and installation) of a measure by the first year energy savings, expressed in dollars.

$$\text{SPP (years)} = \frac{\text{first cost (\$)}}{\text{first year savings (\$)}}$$

For example, if the first cost of a measure is $100 and the first year savings will be $50, the payback period is two years. SPP is relatively easy to calculate; the data required are likely to be available or can be estimated with some reliability; and it gives a rough rule of thumb for comparing measures with varying first costs.

SPP also has some drawbacks if it is used as the only indicator of cost-effectiveness. It does not consider costs or savings in operation and maintenance which could be very significant to your operating budget.

Determining payback period will not automatically tell you if a measure is cost-effective. To make this determination you must set an upper limit for payback periods. If you array all the payback periods associated with energy-saving measures at your site, it might look like Figure 3. Somewhere along the payback line you reach a point of diminishing returns at which it no longer pays to invest in measures with greater payback periods. At this point, the costs begin to outweigh the benefits for the foreseeable future. *Unfortunately, we can never accurately determine that point, because we cannot accurately predict the future.*

If you believe you should invest in all the energy-saving measures with a payback period of five years or less, that implies you know the cost of fuel during each of these five years. If you don't, you would not

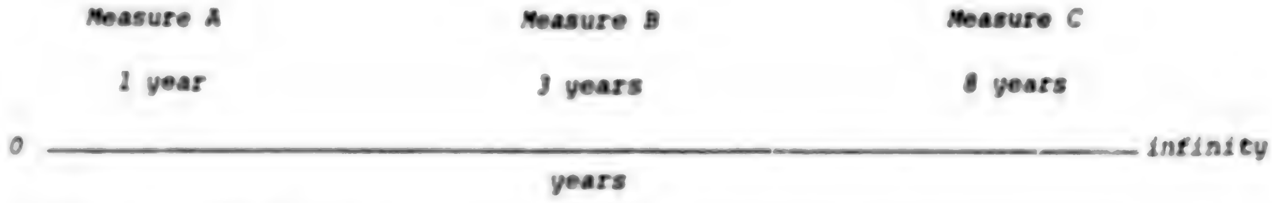

Figure 3 *Payback Periods Projection*

really be predicting economic benefits accurately. But the price of fuel is probably rising faster than the costs of the material and labor for the measure. So, by using simple payback, you will never run out of economically sound, energy-saving measures.

Right now you could undertake everything with a payback period of three years or less; if you refigure the payback period next year on all of this year's rejected measures, some of your rejects will not be rejects anymore. This is because fuel prices will likely rise faster than costs to install the measures. Notice, for instance, that the recommended thickness of attic insulation has been steadily creeping up for several years. This is because even though the price of insulation has gone up, the price of fuel has gone up faster.

PLANNING GUIDE OVERVIEW

The Fish and Wildlife Service is required to develop an effective energy conservation program which will reduce building energy use by 20 percent and petroleum-based fuel use by 30 percent. This Planning Guide is designed to help FWS site managers and personnel to develop energy conservation programs for their sites which will achieve this objective.

All processes in natural and manmade systems involve the transfer of energy in some form. A comprehensive energy conservation/management plan addresses energy flows and budgets in each major part of the system. In this program, we have divided the typical system at FWS sites into major areas where energy savings may be obtained or where renewable energy sources may be tapped. These are:

- Buildings
- Transportation
- Waste Management
- Water Conservation
- Environmental Awareness Program
- On-Site Generation.

With the exception of On-Site Generation (which is covered extensively in Vol. II), this Planning Guide, Vol. I offers for each of the areas listed above:

- Discussion of energy use and opportunities for energy savings
- Step-by-step guidelines, called a "Planning Process," for developing an Energy Conservation Management Plan
- Planning Tools which assist in carrying out the Energy Plan
- Detailed instructions concerning the use of the Planning Process and Planning Tools.

PLANNING PROCESS

Although the specific steps in the planning process vary slightly for each section in the Planning Guide, the overall process is the same, and contains five general steps:

- Collection of Information
- Completion of Data Forms (where applicable)
- Selection of Potential Energy Conservation Measures from Worksheet I series in each section
- Completion of Measures Evaluation: Worksheet II, for each section

- Completion of prioritized list of options from all sections using Summary Plan Worksheet III.

Collection of Information

The first thing you should do in developing your overall energy plan for each specific area covered - Buildings, Transportation, etc. - is to read the material in those sections concerning the technologies involved in energy conservation for that area; various approaches to energy conservation; descriptions of the way the potential conservation measures are organized; and discussion of the reference books.

Completion of Data Forms

Certain sections contain data collection and analysis forms to help you organize information concerning equipment at a site. The information collected on the Data Forms may be useful in evaluating some energy conservation measures. These forms should be completed when data is available and when applicable.

Selection of Potential Conservation Measures: Worksheets I

Each section contains a list of conservation opportunities from which you will select measures to consider for your site. These measures are contained in the Worksheet I series presented at the end of each section. Specific instructions for selecting measures are also discussed in each section.

In reviewing the measures you should first determine whether or not they are applicable to your site. (For example, a measure may not be appropriate because it applies to types of buildings, vehicles, programs, or equipment that do not exist at your location.) Next, you will note that by each measure is an indication of its priority. Immediate priority measures, designated "I," should be implemented as soon as possible since the investment required is very small and the savings generated insure almost immediate payback. High priority measures, designated "H," are those which will require a significant investment but which are certain of economic payback in a very short time. If sufficient station funds are not available to implement these measures, they should be included in the next budget submission for funding. Finally, some measures, designated "F" for "further study," may require detailed analysis to determine if they are economically justified. Assistance may be needed to determine their feasibility.

At any point in the planning process you may find that you need to know more about a measure. The "Technical Reference" gives you sources and page numbers where you can find additional background information or specific data for figuring costs and savings. Some measures do not require references since they are self-explanatory.

After you have reviewed the list of measures, those measures that were judged to be "potential activities" should be written on blank worksheets.

Completion of Worksheets II: Measures Evaluation

The Worksheets II series are designed so that filling in the columns from left to right takes you through a step-by-step decision-making process. (See sample Worksheet II: Measures Evaluation, on following page.)

The basic blank Measures Evaluation Worksheet has columns to be filled in for each measure; the left page includes a preliminary assessment of feasibility and desirability, and the right page examines implementation issues in more detail.

Definitions of the columns on the Measures Evaluation Worksheet follow:

Potential Benefits: The positive effects that you can expect from implementing a specific conservation measure. These qualitative payoffs include both direct benefits and spinoffs. Examples include the type of energy savings expected, the approximate amount of the savings, positive visitor impact, labor savings, reduced maintenance, community goodwill, staff morale, overall resource conservation, etc.

Action Required for Implementation: An initial estimate of the types of activities the refuge or hatchery must undertake in order to carry out a measure. The following types of activity can be entered in this column:

- issuing a policy
- instituting incentives
- training staff
- purchasing equipment or materials
- embarking upon a major construction program
- hiring contractor(s)
- obtaining clearance from outside authorities (surrounding community, state, regional office, etc.)

At this point, no further detail on these activities is necessary.

Barriers to Implementation: Factors which may complicate or prevent implementation of each measure. These may be environmental limitations, conflict with other site activities or purposes, insufficient number of staff, lack of staff motivation, community expectations for the site, visitor needs and viewpoints, estimated amount of cost, administrative opinions, existing refuge or hatchery policies, scheduling conflicts, health and safety considerations, etc.

First Check Point: Initial assessment of how practical and desirable a measure is. You will now need to decide whether or not a measure deserves further considerations by comparing expected benefits with barriers to implementation. At this point in the planning process, you are being asked to make a careful judgment based on the largely nonquantifiable pros and cons of each measure. There are three choices for you to make - "go on," "stop," and "study."

- "Go on" is used when benefits are high and you expect that you can overcome barriers, or when benefits and barriers appear to be of equal value.
- "Stop" is used when benefits are low and barriers are high, or whenever you cannot overcome the barriers.
- "Study" is used when technical advice is necessary in order to examine implementation issues, particularly for measures requiring major capital investments. If you do decide to do a "study," complete the cost column under "implementation issues" to show how much it will cost to contract with experts.

Worksheet II: Measures Evaluation

Measures	Current Status	Potential Benefits	Action Required for Implementation	Barriers to Implementation	First Check Point	Cost	Savings ($ and BTU)	Payback Period	Training Needs	Motivation Problem and Incentives

Implementation Issues: Detailed examination of major factors involved in the implementation of each measure after you have made a "go on" or "study" decision. Each of these issues is discussed below with suggestions about types of information to use when completing these columns.

Costs: Dollar outlays and staff time required to follow through with a measure, or to conduct a feasibility study. Cost information can include purchase of equipment and materials; staff time spent installing, maintaining and operating the measure; training costs; hiring of outside contractors; and monitoring the impact of the measure using mechanical devices, reporting forms, etc. Costs break down into first costs (of installation or implementation) and ongoing maintenance and operating costs. Analyze costs as precisely as possible in this column.

Savings: Dollar and energy savings which might result directly or indirectly from the implementation of a measure over a given period of time. It will be helpful when comparing measures if you express energy savings in actual terms (gallons, kilowatt hours, etc.) and also in Btu. (See Tables, Appendix A, Vol. II).

Payback Period: See Page 6 for detailed discussion.

Training Needs: Additional skills and knowledge which site staff must have in order for them to implement, operate, maintain, and monitor a measure.

Motivation Problems and Incentives: Barriers to introducing a measure which relate to attitudes of staff and visitors, and plans for overcoming these barriers. Motivation problems result when attitudes translate into uncooperative behavior and lack of participation. Motivation problems are frequently stated in terms of "People don't want to..." or "People won't..." Incentives provide a means to increase motivation. They satisfy individuals' needs for recognition by peers and supervisors, authority and responsibility, advancement, personal achievement, personal growth, money, and other rewards.

For the measures in each section designated "I" for "immediate priority," you should focus on how to implement them rather than whether to implement them. To help you work through them quickly, four of the ten columns on the Measures Evaluation Worksheet may be omitted: "potential benefits," "first checkpoint," "savings," and "payback period."

A sample completed Worksheet II: Measures Evaluation has been included in each section following the list of Potential Conservation Measures.

Completion of Worksheets III: Summary Plan

Once the Worksheet II series has been completed (using one set for each section), this information should be pulled together to make one overall site energy conservation plan. You will do this by using the format provided in Worksheet III: the Energy Management/Conservation Plan Summary. This list will be your summary of measures for conserving energy at your site based on the analysis provided in the Planning Guide.

By now you should have developed projects from several different planning areas, such as buildings, transportation, waste management and environmental awareness. Some projects are justifiable on economic grounds - the investment in time and money to accomplish the project will be more than offset by the cost savings resulting from reduced site energy use. Some projects may not produce large energy savings for your refuge or hatchery, but would make a considerable contribution to overall community energy savings. Still other projects may be justifiable for their value in communicating a conservation message to employees and the public. With such a mixed bag of possible conservation projects before you, it may not be obvious which should be undertaken first.

The purpose of this section is to give you a process for producing an "integrated" energy management plan. In using this integration process, you must use judgment as to what makes the most sense for your refuge or hatchery.

Worksheet III includes the following entries:

- Measure - a brief description or name of the conservation measure in question, obtained from an appropriate Worksheet II: Measures Evaluation.
- Benefits - the benefits of the particular measure in question, obtained from the Measures Evaluation Worksheet.
- Estimated Energy Savings - the energy savings resulting from the measure as shown on the Measures Evaluation Worksheet.
- SPP - the simple payback period of the measure as shown on the Measures Evaluation Worksheet.
- Planned Implementation (FY) - the fiscal year when you plan to implement the measure in question.
- Funding Source - an indication of the source of money for accomplishing the project, such as current FY O&M funds future budget, interagency demonstration funding, etc.
- Responsible for Implementation - the person on the refuge or hatchery staff who will be assigned responsibility for implementing the project.

Step 1. Group Measures According to Priority

The list of energy conservation measures contained in each section of the Guide provided a general indication of each measure's priority, being designated either "immediate," "high priority" for funding, or requiring "further study." In this step you should group all measures of similar priority from each planning area together. For example, if you had found measure 1.8 of the buildings area (closing off unused areas); measure 2.1a from the transportation area (establishing preventive maintenance schedules and checklists); and measure 1.3a of the water management area (installing flow-reducing shower heads and faucets) to be applicable to your station, you would group them together.

Projects which do not produce cost savings directly for your site should still be included in one of the three general priority categories. Use your best judgment in determining which category is appropriate. The objective here should be to produce maximum benefits for the least cost.

Step 2. Rank Measures Within Each Grouping

You should now have three groups of measures: one set identified as immediate priority, one set identified as high priority for funding and one set identified as requiring further study.

Immediate priority projects are those which you should implement as soon as possible. The ranking of these measures can be accomplished quite simply by doing those which are easiest first. If you are unsure of which measure is easiest to implement, you can review the Required For Implementation column of the Measures Evaluation Worksheet.

Measures grouped under the high priority for funding category should be ranked primarily on the basis of Simple Payback Period (SPP), that is, the lower the SPP, the higher the rank. Thus, a project with an SPP of 1.2 years should be ranked above a project with an SPP of 3.4 years. In some cases you may want to rank a project with a low SPP (but still acceptable) and low investment cost above one with a higher SPP and high investment cost because sufficient funding is immediately available for the first but not the second measure. For example, project A has an SPP of 5.6 years and costs $150 to implement. Project B has an SPP of 2.1 years and costs $1,500 to implement. Because of effective conservation actions, $200 in station O&M funds are available for further conservation investments. In this case it would make sense to rank project A above project B.

Comparing projects which do not produce direct energy and cost savings for your station with those that do is somewhat more difficult. No hard and fast rules can be given for this situation. You will have to use your best judgment here, realizing on the one hand that primary emphasis should be given to measures producing direct cost savings to the station, but that the FWS does have an obligation to contribute to community energy conservation.

Finally, for projects which require further study, you should review the potential benefits and energy and cost savings for each project. You will not, of course, be expected to implement these projects until they have been adequately studied. The objective here should be to determine which project to study first. Here again, all you need to do is apply judgment in determining those which will produce maximum benefits and savings and rank accordingly.

Step 3. Determine Funding Limits and Sources

In this step you should determine the amount of money available in your station's budget that could be made available for energy conservation investments. Often, circumstances will arise which make it possible to fund small, high-priority projects from station funds. For example, a wetter than normal year could mean reduced pumping costs at your refuge or hatchery, which could mean that money is available for conservation investments. Regional and national sources as well as potential demonstration project funding from other agencies are also possibilities for project funding which should not be overlooked.

Your objective here should be to determine the amount of money that is realistically available for conservation investment. Guidance should also be available from your regional office as well as FWS headquarters regarding energy conservation budget submissions for future years.

You should now be able to determine which projects are "immediate" and should be implemented within the current fiscal year. All "high priority" projects should be accomplished by FY 1985, and your plan should be developed accordingly, keeping in mind the Service's mandated requirements. All studies for projects "requiring further study" should be completed by FY 1981.

A sample completed Worksheet III: Summary Plan, along with a sample cover letter for sending it to the Regional Director are included in the Appendix.

CONCLUSION

Energy management planning involves everyone. Because energy flow occurs in all natural processes, every specialist who knows his system well can make a contribution to the efficiency of the whole. In FWS operations, the maintenance divisions will have a special responsibility: they must find ways to increase efficiency and minimize the costs of maintaining the system. Concessionaires, too, if part of the system, will be involved in planning energy management programs. These groups can perform more efficiently if they have the support of management and of other divisions, and of agency professionals who contribute specialized expertise.

> NOTE: You must involve everyone on your site staff in the development of the site plan if you wish them to be motivated to carry out the plan. Your first reaction may be that clerical, biological and other non-maintenance personnel would probably not contribute much to energy conservation plan development because of the technical nature of many of the measures. However, these are the people living in the buildings and carrying out the operations throughout the site. They are also the ones who control most of the energy environment, setting thermostats, turning lights on and off, driving vehicles, producing waste products, operating laboratory equipment, etc. Their ideas and suggestions can contribute to a more comprehensive and workable plan and should not be overlooked.

Also important to you as you are developing your energy saving plan is the Regional Energy Coordinator. It is the Coordinator's responsibility to assist you in working out problems, in gaining access to technical information, and in making your more difficult judgments.

Sites in the FWS are windows into the world of nature and our nation's history. They preserve the ecological and cultural roots from which today's society has grown. The millions of visitors who come each year to enjoy the resources at refuges and--increasingly--hatcheries and other areas, experience the links between man, nature and the past that often are lost in the bustle of urban life. These special places can be showcases of wise energy management, illustrating how a better balance between man and nature can be achieved. Of course, the opposite is true, too; as the public becomes increasingly aware of the need of economy and efficiency in energy systems, poor energy management will be noticed by visitors and interested groups.

Energy use in every Federal government operation will be scrutinized more closely in years to come. Through planning, FWS sites can become models of wise energy management that will serve as examples to other government agencies and the general public.

APPENDIX

SAMPLE

Regional Director
U. S. Fish & Wildlife Service
Federal Building, Ft. Snelling
Twin Cities, MN 55111

Transmitted is the completed Energy Management/Conservation Plan Summary for the FWS Clear Lake Hatchery. This has been completed using the FWS Planning Guides, and summarizes the best opportunities available for energy and cost savings at this site.

Sincerely,

Richard Daly

Richard Daly,
Chief Biologist

Enclosure

SAMPLE

WORKSHEET III

ENERGY MANAGEMENT/CONSERVATION PLAN SUMMARY

Measure	Benefits	Estimated Savings $/Energy	Estimated Cost	SPP	Planned Implementation (FY)	Funding Source	Responsible Implementation for
IMMEDIATE PRIORITY							
2.7 (WASTE MANAGEMENT) REDUCE FREQUENCY OF COLLECTION (FROM TWICE/WEEK TO ONCE/WEEK)	• FUEL SAVINGS FOR COLLECTION TRUCK • SAVINGS IN STAFF TIME	$47/YEAR 43 GAL. OF GASOLINE	0	IMME-DIATE	1980	IN-STATION O & M	
4.1 (BUILDINGS) REMOVE UNNECESSARY FLUORESCENT LAMPS	• ELECTRICITY SAVINGS • NO PERCEIVABLE DECREASE IN ILLUMINATION	$100/YEAR 1997 KWh	$120	1.2 YEARS	1980	IN-STATION O & M	
1.3 (WATER CONSERVATION) INSTALL FLOW REDUCING SHOWERHEADS & FAUCET AERATORS	• SAVE 9,000 GAL. OF WATER ANNUALLY	$46/YEAR 560 KWh	$91 — INSTALLED	2.0 YEARS	1980	IN-STATION O & M	
2.1 (TRANSPORTATION) ESTABLISH PREVENTATIVE MAINTENANCE SCHEDULES AND CHECKLISTS	• LESSENS DOWN TIME • IMPROVES EFFICIENCY	$230/YEAR 212 GAL. OF GASOLINE	$640 (MOSTLY LABOR)	2.8 YEARS	1980	IN-STATION O & M	

SAMPLE

WORKSHEET III

ENERGY MANAGEMENT/CONSERVATION PLAN SUMMARY

Measure	Benefits	Estimated Savings $/Energy	Estimated Cost	SPP	Planned Implementation (FY)	Funding Source	Responsible Implementation for
I.A.2 (ENVIRONMENTAL AWARE.) INTERPRETIVE PROGRAM FOR ELEMENTARY SCHOOL STUDENTS ON ENERGY FLOW IN FOREST ENVIRONMENTS	• GREATER UNDERSTANDING OF ECOSYSTEM AND ENERGY RESOURCES	NONE TO THE SITE	$400 (STAFF TIME)	N/A	1980	INSTATION I & R	
HIGH PRIORITY							
2.4 (TRANSPORTATION) USE RADIAL TIRES	• SAVE GASOLINE • LONGER TREAD LIFE	$312/YR 287 GAL. OF GASOLINE	$490 GREATER THAN BIAS PLY TIRES	1.7 YEARS	1981	VEHICLE MAINTENANCE BUDGET	
9.3 (BUILDINGS) ADD TIME CLOCKS ON SELF-CONTAINED COOLING UNITS	• ELIMINATE COOLING DURING NON-OCCUPANCY	$137/YR 2741 KWH	$600 - INSTALLED	3.7 YEARS	1982	O & M BUDGET REQUEST	

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Page

SAMPLE

WORKSHEET III

ENERGY MANAGEMENT/CONSERVATION PLAN SUMMARY

Measure	Benefits	Estimated Savings $/Energy	Estimated Cost	SPP	Planned Implementation (FY)	Funding Source	Responsible Implementation for
II.C.1.l. (ENVIRONMENTAL AWARE.) INTERPRETIVE DISPLAY ON HOMEMADE SOLAR COLLECTORS	• INCREASED AWARENESS OF SOLAR ENERGY & MATERIALS REQUIRED TO BUILD A COLLECTOR	NONE – COLLECTOR FOR DEMONSTRATION PURPOSES	$200 – MATERIALS $400 – STAFF TIME - - - - - $600 – TOTAL	N/A	1983	I & R BUDGET REQUEST	
1.2 (WATER CONSERVATION) IN RENOVATIONS, INSTALL SHALLOW TRAP TOILETS	• REQUIRES ONLY 3 1/2 GAL./FLUSH	$46/YR 540KWH	$220 - INSTALLED	4.8 YEARS	1983	O & M BUDGET REQUEST	
3.4 (WASTE MANAGEMENT) INSTALL CLEARLY LABELED INDOOR & OUTDOOR CONTAINERS TO COLLECT ALUMINUM CANS FOR RECYCLING	• SELL WHAT HAS BEEN CONSIDERED WASTE	$89/YEAR (FROM THE SALE OF RECYCLED CANS) NO DECREASE IN ENERGY USE FOR THE SITE	$220 - MATERIALS $210 – LABOR - - - - - $430 - TOTAL	4.8 YEARS	1984	O & M BUDGET REQUEST	

SAMPLE

WORKSHEET III

ENERGY MANAGEMENT/CONSERVATION PLAN SUMMARY

Measure	Benefits	Estimated Savings $/Energy	Estimated Cost	SPP	Planned Implementation (FY)	Funding Source	Responsible Implementation for
FURTHER STUDY							
5.3 (TRANSPORTATION) REDUCE HIGHWAY LIGHTING (CHANGE FROM MERCURY VAPOR TO HIGH PRESSURE SODIUM BULBS)	• SAVINGS OF 79 WATTS/LAMP • EQUAL LUMENS/WATT	$433/YEAR 8650KWh	$2250	5.2 YEARS	TECHNICAL ASSISTANCE– 1981 PROJECT– 1985	O & M BUDGET REQUEST	
2.2 (WATER CONSERVATION) REUSE ONCE USED WATER FOR A SECONDARY USE (WATER TREATED AND USED FOR SMALL-SCALE IRRIGATION)	• REDUCED WATER USE & SEWAGE FLOW • EXAMPLE TO COMMUNITY	$160/YEAR NO NET ENERGY SAVINGS	$985	6.2 YEARS	TECHNICAL ASSISTANCE– 1981 PROJECT– 1985	O & M BUDGET REQUEST	
4.3 (WASTE MANAGEMENT) PRODUCE FERTILIZERS AS A BY-PRODUCT OF OTHER PROCESSES	• REDUCED WASTE • REDUCED NEED TO PURCHASE FERTILIZER	$230/YEAR NO NET ENERGY SAVINGS	$1900	8.3 YEARS	CONSULTATION AND TECHNICAL ASSISTANCE– 1981 PROJECT– 1985	O & M BUDGET REQUEST	

SAMPLE

WORKSHEET III

ENERGY MANAGEMENT/CONSERVATION PLAN SUMMARY

Measure	Benefits	Estimated Savings $/Energy	Estimated Cost	SPP	Planned Implementation (FY)	Funding Source	Responsible Implementation for
2.4 (BUILDINGS) CONVERT EXISTING ROOF INTO SOLAR COLLECTOR (HOT WATER USE)	• USE OF RENEWABLE ENERGY SOURCE • EXAMPLE TO COMMUNITY	$200/YEAR 3995 kWh	$1955	9.8 YEARS	TECHNICAL ASSISTANCE- 1981 PROJECT- 1985	O & M BUDGET REQUEST	
II.C.1.l. (ENVIRONMENTAL AWARE.) INTERPRETIVE DISPLAY ON WATER REUSE, SOLAR COLLECTORS, AND FERTILIZER PRODUCTION	• VISITOR UNDERSTANDING OF SYSTEMS USED • OPPORTUNITIES FOR VISITORS TO USE SIMILAR SYSTEMS	NONE TO THE SITE	$250- MATERIALS $500- STAFF TIME $750- TOTAL	N/A	1986	I & R BUDGET REQUEST	

GLOSSARY

ABSORPTION CHILLER
A refrigeration machine using heat as the power input to generate chilled water.

AERATORS
Units added to faucets (normally kitchen) to introduce air into the stream of water to reduce splashing.

AEROBIC DECOMPOSITION
The action of bacteria that can live only in the presence of oxygen, to break down organic wastes into soil conditioners and water.

AEROBIC TREATMENT UNITS
Units in which the action of bacteria (that can live only in the presence of oxygen) is used to break down organic wastes into soil conditioners and water.

AERODYNAMIC DRAG
The retarding force acting on a vehicle (truck, airplane, etc.) moving through the air or any gaseous fluid parallel and opposite to the direction of motion.

AIR SHIELDS FOR LONG DISTANCE TRUCKS
Shields or deflectors used to streamline the truck and reduce air resistance.

AMBIENT
Surrounding, i.e., ambient temperature is the temperature in the surrounding space.

ANAEROBIC DIGESTION
The action of bacteria in the absence of oxygen to break down wastes into soil conditioners and methane gas.

AQUACULTURE
The culture of plants and animals in fresh water for human and animal foods.

ASHRAE
American Society of Heating, Refrigerating and Air Conditioning Engineers.

ATTIC HATCHWAYS
Passages giving access to an enclosed space above the top story of a building.

BAFFLE
A device used to check, retard, or divert flow.

BALLASTS
In lighting, a device used in starting a circuit for fluorescent and other types of lamps. Otherwise, extra weights for stability.

BARRIERS TO IMPLEMENTATION

Factors which may complicate or prevent implementation of an energy conserving measure.

BIOCONVERSION

Conversion of a form of energy not directly serviceable to man to one that will service his particular needs by living systems. Examples: processing of organic wastes into methane and other gasses by bacteria; storing solar energy in chemical form by energy crops.

BIODEGRADABLE

The characteristic of decomposing resulting from the action of microorganisms.

BIOFUELS

Fuels derived from living or recently living plant materials. Examples: wood, methane from sludge, alcohol from distillation.

BIOGAS

Gas generated by anaerobic digestion of organic wastes.

BIOLOGICAL TOILETS

Recycling toilets based on biological principles of waste digestion; body wastes and toilet tissue are turned into water by the continuous action of enzymes and bacteria, both aerobic and anaerobic, in the base of the commode.

BIOMASS

A collective term that includes all plant material, from bacteria to trees, living or recently living.

BIOMASS ENERGY

Energy from biological sources.

BLACK WATER

Effluent from toilets.

BLOW DOWN LOSSES

Losses occuring with the discharge of water from a boiler or cooling tower sump to reduce the high proportion of total dissolved solids in the water.

BRITISH THERMAL UNIT (BTU)

A unit of measure equivalent to the amount of heat energy required to raise the temperature of one pound of water one degree Fahrenheit at 50°F.

BUILDING LOAD

The amount of energy in Btu or kwhs required to supply a building with energy to maintain desired indoor comfort conditions and to operate building equipment.

CANWELL SYSTEM

Canadian Water Energy Loop

CARBURETION

To combine chemically with a carbon; to enrich by mixing with volatile carbon compounds.

CELLULOSE

A relatively tough and rigid substance which constitutes the walls of plant cells.

CLUTCHED FAN

A radiator fan on trucks or large vehicles that is engaged to, or disengaged from, the crankshaft in the engine by a clutch activated by a thermostat connected through the engine block to determine the temperature of the cooling fluid.

COAGULATION SEDIMENTATION

Where coagulating agents are introduced into waste water to speed up sedimentation by causing the suspended material (small solid particles) to come together into larger, heavier masses and settle out faster.

COGENERATION

Careful preservation, protection and management of a natural resource to prevent exploitation, destruction or neglect. In energy conservation, cutting back on services or improving efficiency in order to save energy.

COMBUSTION

A chemical process (as in oxidation) accompanied by the evolution of light and heat: an act or instance of burning.

COMPOSTING

Biochemical decomposition of organic wastes to produce humus, a soil conditioner.

CONSERVATION

Careful preservation, protection and management of a natural resource to prevent exploitation, destruction or neglect. In every conservation cutting back on services or improving efficiency in order to save energy.

CONVERSION

The change from one form or use to another.

COOLING TOWERS

Devices that cool water directly by evaporation.

COST/BENEFIT WORKSHEET

A form used to collect and compare all costs and benefits, or savings associated with the installation, operation, and maintenance of an energy saving measure. This information presented on the worksheet deals only with the direct financial implications of a particular measure.

DECIDUOUS TREES

Trees which shed their leaves at the end of the growing season.

DEHUMIDIFICATION

The removal of moisture from the air.

DEMAND FAN

A fan whose operation is controlled by changes in temperature.

DESICCANT

A substance that can absorb moisture.

DIASTROPHISM

The process of deformation that produces in the earth's crust its continents and ocean basins, plateaus and mountains, folds or strata, and faults.

DRIP IRRIGATION

A irrigation system consisting of a hose or plastic tubing and emitters. The emitters apply the water in a slow, dripping manner, and the water is drawn into the soil by capillary action.

DUAL DUCT SYSTEMS

Space conditioning systems having two ducts - one trunk to supply warm air and the other to supply cool air to mixing boxes. Air is then delivered through one duct to the conditioned space. Warm and cool air are proportioned in the mixing boxes to provide supplies of air to the room at temperatures which meet the thermal demand in that room.

DUAL FLUSH TOILETS

Toilets which have a device that makes it possible to select the correct flush for either solid or liquid wastes.

EARTH BERMS

Raised strips of ground used as a narrow shelf, path or ledge.

ECONOMIZER CYCLE

A method of operating a ventilation system to reduce refrigeration load. In cooling a building, whenever outdoor air conditions are more favorable (lower heat content) than indoor return air conditions, the quantity of outdoor air is increased.

ECOSYSTEM

A complex ecological community and environment forming a functional whole in nature, which processes energy, maintains structures, sustains cycles, and operates according to energy laws. All ecosystems have some common characteristics which follow energy principles; i.e., all have groups that are energy producers and groups that are energy consumers.

EFFLUENT

A liquid, solid or gaseous product, frequently waste, discharged or emerging from a process.

END USE

In a sequence of energy conversions, the last use of energy to perform a desired function.

ENERGY

Power. The capacity to do work.

ENERGY ACCOUNTING

A method used to show the consumption of nonrenewable fuels and power in energy-using systems.

ENERGY CONSERVATION MANAGEMENT PLAN

A plan setting forth effective ways of using less energy to perform necessary tasks. The energy conservation management plan also identifies measures for conserving energy, and schedules for implementing these measures.

ENTHALPY

The total heat content of air; the sum of the enthalpies of dry air and water vapor, per unit of dry air.

EVAPORATIVE COOLING

The cooling of air by the evaporation of moisture into that air.

EVAPORATOR

A heat exchanger which adds latent heat to a liquid, changing it to a gaseous state In a refrigeration system, it is the component which absorbs heat.

EVAPOTRANSPIRATION

The combined effect of evaporation of moisture into the air and transpiration, the method by which plants remove moisture from the soil and release it into the atmosphere.

FAN COIL SYSTEM

A heating and/or cooling device that blows air through a coil.

FEASIBILITY STUDY

A study which determines the likelihood of work being successfully completed to achieve a desired goal.

FILTRATION

A method for removing suspended solid particles from liquids by passing the liquid through filter materials or screens whose gaps or holes are smaller than the size of the smallest expected particle to be filtered.

FIN WALL

The extension of an existing wall to deflect winds.

FIN TUBE

A tube with metal sheets attached as fins, to increase the heat transfer area.

FIRE PLACE DAMPERS

Valves or plates (as in the flue of a furnace) for regulating the draft; a device used to vary the volume of air passing through an air outlet, inlet, or duct.

FLOCCULATION

Causing susperded matter in fluids to come together into large masses.

FLUE

An enclosed passageway for directing a current of air. The flue in a chimney conveys flame and smoke to the outer air. In a steam boiler, the flue is a pipe for conveying flame and hot gases around or through water in the boiler.

FLUE GAS ANALYZER

A device for analyzing fuel/air rations in flue gases.

FLUORESCENT LAMP

An electric discharge lamp in which light is produced by the passage of an electric current through a metallic vapor or gas enclosed in a tube or bulb.

FLY ASH

Fine solid particles or noncombustible ash carried out of a bed of solid fuel by the draft.

GLAZING

Glass or plastic set in frames to make windows.

GRADIENTS

The rates at which roads rise or fall vertically; the slopes of roads.

GREYWATER

All the waste water produced in a household other than toilet wastes.

HEAT EXCHANGER

A device which transfers heat from one substance to another substance while keeping the substances separate and unmixed.

HEAT RECLAMATION

A method for capturing energy in the form of heat which would otherwise be injected into the atmosphere.

HOT CONDENSATE HEAT EXCHANGER

A heat exchanger where flash steam returned from a steam system is reduced to hot condensate at atmospheric pressure.

HOT DRAIN EXCHANGER

A heat exchanger installed in the drains of buildings and/or systems that use large quantities of hot water. Heat from the exchanger can be used to preheat the domestic hot water.

HOT GAS EXCHANGER

A heat exchanger installed in the hot gas line between the compressor and chiller of a large refrigeration system.

HVAC SYSTEMS

Heating, ventilation, and air conditioning systems.

HYDROLOGY

The science that deals with the properties, distribution, and circulation of water on the surface of the land, in the soil or underlying rocks, and in the atmosphere.

HULL DRAG

The friction of water on the outer surface (hull) of a ship which slows or retards its movement through the water.

HYDROLYSIS

A chemical process of decomposition involving splitting of a chemical bond and addition of the elements of water, hydrogen and oxygen.

HYDRONIC DISTRIBUTION SYSTEM

A system of providing heat to a building through the use of a hot water loop.

IMPELLER

The rotating member of a centrifugal pump, which receives inflowing water at its center and accelerates it to the periphery, where it is discharged to a pumping system.

INCANDESCENT

Glowing or white with heat. An incandescent light bulb produces light from a tungsten wire heated white hot.

INDUCTION SYSTEM

Heating material by means of an electric (induction heating) current made to flow through the material or its container by electromagnetic induction.

INFILTRATION

The leakage of outdoor air into a building through cracks around doors, windows and other openings.

INTEGRATION

One method to cut consumption of energy use is that of integrating various specialized components (e.g., cogeneration systems using waste heat to produce steam to turn electric generators).

INTERREFLECTANCIES

The reflections of light given off by the color of the painted room.

INVERTERS

Devices for converting direct current (dc) into alternating current (ac) by mechanical or electronic means.

LEAK SIGNALLING BALLCOCK

A water control valve for toilets that is either on or off. A leaking toilet will cause the valve to turn the water on full when the leak has caused the water to drop to a preset level in the tank. The water going on and off periodically will signal that there is a leak.

LIFE CYCLE COSTING

The process of accounting for capital and operational costs of a building, an energy conservation measure or other product, over its useful life.

MACADAM

Pavement of broken stone with a bituminous binder.

MARICULTURE

Cultivation of marine (salt water) species of plants and animals for human use.

METAMORPHIC ROCK FORMATION

A pronounced change in rock affected by pressure, heat, and water that results in a more compact and more highly crystalline condition.

METHANE

A colorless, odorless, flammable, gaseous hydrocarbon that is a product of the decomposition of organic matter in marshes and mines or of the carbonization of coal and is used as a fuel and as a raw material in chemical synthesis. Methane is the major component of natural gas.

METHANOL

Wood alcohol, a combustible fuel.

MICRO-CLIMATE

The consistent local climate of an area, usually a small site or habitat.

MODULAR

Composed of modules, or interrelated parts.

MODULAR BOILER

A boiler system made up of several modules in order to increase seasonal efficiency. Fluctuations of load may be met by firing more or fewer boiler modules.

MONITORING

Establishing a fuel and maintenance cost accounting system by maintaining complete and accurate records of monthly and annual energy consumption. In transportation, for example, monitoring would call for records of mileage, fuel consumption, and direct maintenance labor hours and cost of replacement parts for each vehicle.

MULCH

A protective covering such as leaves, manure, or hay, placed around plants to prevent evaporation of moisture and freezing of roots.

MULTI-ZONE SYSTEM

An HVAC control air-handling unit that provides hot and cold air and facilities for mixing these at the unit to give different supply temperatures to a number of zones.

NON-RENEWABLE ENERGY SOURCE

An energy source that is virtually impossible to recreate within the foreseeable future, such as fossil fuels (oil, coal, natural gas) and uranium.

OFF-LINE BOILER

A boiler that is idling or standing by to supply heat when needed. It is isolated by closing valves or dampers.

OIL-FLUSH TOILETS

A closed-loop toilet system that uses a white, low-viscosity mineral oil as the flushing fluid. Wastes are carried to a gravity separation tank where the oil floats to the top and the water saturated wastes sink to the bottom. The oil is drawn off the top through filters containing chlorine crystals and activated charcoal, and re-circulated to the commodes.

ORGANIC WASTE

Waste derived from living organisms.

OVERDRIVE

An automotive transmission gear that transmits to the drive shaft a speed greater than the engine speed.

PARAPET

A low wall, railing, or elevation of earth or stone to protect the edge of a platform, roof, or bridge.

PARASITE

An organism that depends on a source outside itself for existence or support without making a useful or adequate return.

PARASITIC DISTRIBUTION LOSSES

Heating or cooling losses from the distribution network of a heating or cooling system.

PARASITIC LOAD

The energy required to deliver energy from the primary energy conversion equipment to the building load.

PASSIVE COMPONENTS OF HEATING/COOLING SYSTEMS

Components of the systems which do not actively heat, cool, or move air or other heat transfer media through the system, e.g., ducts, pipes, filters, and louvers.

PASSIVE SOLAR

Treatments of a building structure which help the structure become a trap for light and heat from the sun. These treatments are often the least expensive methods for utilizing the sun's energy.

PATHOGENIC CHEMICALS

Chemicals that are capable of causing disease or harm.

PIPE CHILLER

A refrigeration machine using heat as the power input to generate chilled water.

PIT PRIVY

A large hole in the ground, covered with a slab or squat plate in which excreta and other organic matter are added and topped with earth; a type of compost privy.

PHOTOSYNTHESIS

The synthesis or building of glucose from carbon dioxide and water by specialized structures and substances in the cells of green plants.

PHOTOVOLTAIC CELL

A semiconductor device that converts solar energy into electricity.

PLAIN SEDIMENTATION

Where waste water with suspended solids is allowed to set long enough for most of the solids to settle out before the remaining fluid is syphoned off.

PLATE TECTONICS

Tectonics relating to the deformation of the earth's crust. The forces involved in or producing such deformation and the resulting forms.

POTABLE

Fit or suitable for drinking.

PRESSURIZED TOILET TANKS

A toilet tank which uses air pressure to assist water in flushing the bowl. The air in the tank that is replaced by the entering water is compressed rather than being allowed to escape. When the flush button is pushed, the compressed air forces the water down into the bowl, providing higher pressures for the flush.

PRIMARY ENERGY CONVERSION EQUIPMENT

Equipment which converts fuels and electricity to provide conditioned air, light, hot water, and other work products. This equipment includes gas and oil burners/furnaces, refrigerators, chillers and compressors, and electric lighting systems.

PRIMARY TREATMENT

The first stage in sewage treatment that consists of a series of physical operations whereby large, floating solids are removed by screening and heavy solids are removed by settling.

PYROLYSIS

A chemical change brought about by the action of heat.

RACEWAYS

Canals for currents of water.

RECOVER WASTE HEAT

Heat recovery from the combustion of solid wastes in a refuse incinerator or from processed steam plants.

RECYCLE

To pass through or undergo again, as for further treatment, change, use, etc.

REFLECTED RADIATION

Solar radiation in the form of heat and light that is reflected from adjacent surfaces of a building or buildings, trees and shrubs, or the ground.

RENEWABLE ENERGY SOURCES

Energy sources that are unlikely to be exhausted in the near future, such as solar radiation, photosynthesis, and its products and by-products, wind, waves, tides, falling water, and geothermal heat.

RETROFIT

The modification of an existing building or other system to affect favorable consumption characteristics, the retroactive modification of an existing building or machine.

ROLLING STOCK WHEEL BEARINGS

Bearings between the wheel and axle of automobiles, trucks, trains, or any form of vehicle that runs on wheels.

ROOF POND for heating and cooling effects

Containers of water placed on the roof of a building to store solar heat. The roof pond may be contained in galvanized sheet pans supported on timbers that run the length of the house.

ROOF SPRAY

A system that reduces heat gain through a roof by cooling the outside surface with a water spray.

SAND FILTRATION

Waste fluids are run through large beds of sand to filter out suspended solids.

SECONDARY TREATMENT

Basically an aerobic process in which naturally occurring bacteria break down most of the degradable material left from primary treatment.

SEDIMENTARY ROCK FORMATION

A geological formation created by fragments of rock transported from another source and deposited in water. Sandstones and shales formed by precipitation from solutions and formed from secretions or organisms are sedimentary rocks.

SELF-CLOSING FAUCET

A single zone duct system uses the same set of ducts to distribute hot air from the furnace in the winter and cold air from the air conditioner in the summer.

SILVICULTURE

The cultivation of trees and forests for useful purposes.

SITE RETROFITTING

In landscape planning for energy conservation, altering the landscape of an existing site to create a more temperate environment by utilizing natural energy resources and landscape elements to reduce the demand on the heating or cooling system of buildings located on the site.

SLUDGE

Precipitated solid matter resulting from water sewage treatment processes. The solid portion of sewage.

SLURRY

A thin, watery mixture of a fine, insoluble material.

SOLAR COLLECTOR

Devices, often in the form of panels, which collect and store solar heat/energy.

SOLAR HEAT GAIN

The increase in the amount of available heat due to exposure to the sun.

SOLAR RADIATION

Energy from the sun. It may be direct, diffuse, or reflected.

SPACE LOAD

The quantity (heating, cooling, electricity) required by a space.

STEAM ATOMIZER BURNER

A burner in which a small quantity of steam is mixed with atomized (separated into very small dorplets) fuel prior to combustion.

STRATIFIED CHARGE

An automobile engine with a dual combustion chamber and two intake valves in each cylinder. A rich mixture of fuel and air is fed into the upper smaller chamber where it is ignited by a spark from the spark plug. The burning rich mixture then ignites the lean mixture in the lower, larger chamber to produce a more complete combustion.

SYSTEM

A set of interrelated elements. Anything can be understood as a system if it can be seen as a complex of interdependent parts. In energy technology, a set of mechanical subsystems affecting the efficiency of energy consumption.

SYSTEMS APPROACH

A method for addressing problems that calls for an analysis of systems by considering both the whole systems and the parts which make up that system.

TANDEM RIGS

In transportation, a vehicle having close-coupled pairs of axles.

TERMINAL REHEAT SYSTEM

Terminal reheat systems were developed to overcome the zoning deficiencies of single duct systems and are designed to give closer control of relative humidity in selected spaces. The system allows each different zone to be individually controlled.

TERTIARY TREATMENT

A third treatment step whereby chemical and physical processes reduce contaminants, such as phosphates, nitrates, and other dissolved materials.

THERMAL BARRIERS

Barriers which control the flow of heat and cold. Drapes and shutters can both serve as thermal barriers.

THERMAL SYSTEMS

Systems that demand or produce heat.

THERMAL TRANSMISSION HEAT LOSS

The transmission of heat through the walls, windows, and doors of a building.

TOILET DAMS

Blockages (dams) placed in the tank to limit the amount of water used per flush.

UNITARY HEAT PUMPS

Single unit refrigeration systems possessing the capability of reversing flow so that the output can be either heating or cooling.

U-VALVE

The heat flow rate (air-to-air) through a given construction assembly, such as a wall or window, expressed in Btu per hour per square foot times the difference in indoor and outdoor temperatures.

VARIABLE FLUSH

A conventional toilet with an attachment that allows the flush cycle to be operated for any portion of a full flush by simply holding down the trip lever for the correct period of time.

VARIABLE VOLUME AIR SYSTEMS
An all-air system that matches the cooling load with a variable volume of air cooled to the same temperature. Refrigeration and fan energy closely parallel to the system's actual cooling load.

VENTILATION
The process of supplying and/or removing air by natural or mechanical means to or from any space. The air may or may not be conditioned.

VESTIBULE
A passage, hall, or room between the outer door and the interior of a building.

VOLTMETER
An instrument for measuring in volts the differences of potential between different points of an electrical circuit.

WASTE MANAGEMENT
Those activities involved in collecting, transporting, processing, and disposing of waste materials and finding productive uses of "waste" through recycling, composting, or on-site energy generation.

WATER VOLUME REDUCERS
In toilets, devices that can help reduce the amount of water used each time you flush. These include low flush toilets, pressurized toilet tanks, dual and variable flush devices.

WIDGET
Imaginary engine part.

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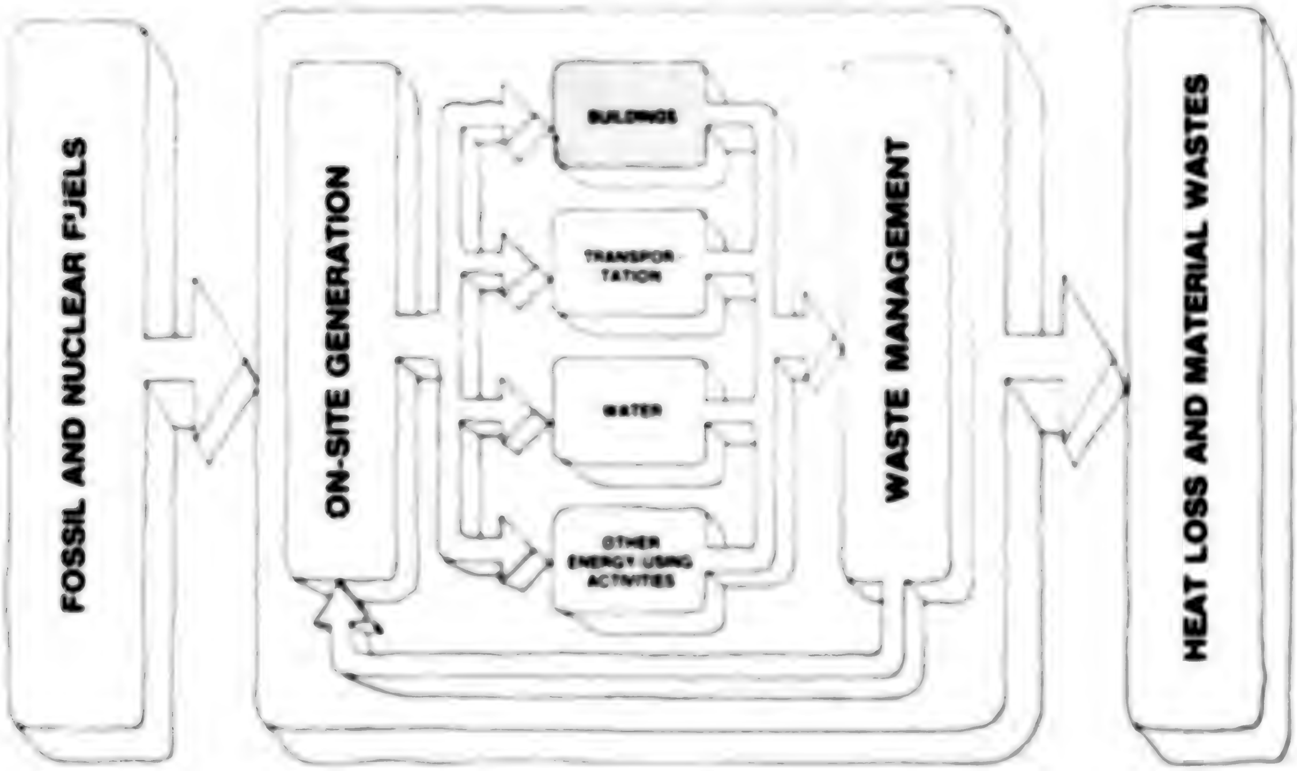
Buildings

VOLUME I
BOOK 2


SITE ENERGY-USING FUNCTIONS

This section on energy conservation in Buildings is part of a two volume Planning Guide designed to help you formulate an overall site-specific Energy Conservation Management Plan. It provides you with technical information about energy use in buildings as well as instructions for choosing and developing appropriate measures for making your buildings more energy efficient.

BUILDINGS

BUILDINGS AS AN ELEMENT OF THE SITE SYSTEM

Energy use in buildings represents the largest percentage of energy consumption at most FWS sites. A wide range of energy-using activities occurs in buildings: conducting routine business in offices at the site; storing materials in warehouses; and maintaining government employee residences. A site may also have research and development facilities used for special projects.

To help you learn about energy use in the buildings at your site, this section provides an overview of buildings as energy-using systems, and a quick look at places where energy waste is likely to occur. At the end of the section you'll find a short discussion on how to use the additional reference material provided to help you complete the planning process.

BUILDINGS AS ENERGY-USING SYSTEMS

Building systems and components process energy inputs to provide desired functions. As with other systems, there is some waste each time a desired function is provided. Energy waste in buildings is inevitable, as it is in other systems, since perfectly efficient energy conversion is impossible. Figure 1 shows a residence that uses oil as the principal energy source, for one desired function of a building's energy-using systems - space heating. If it's typical, the oil furnace in this residence converts about 60-80% of the energy in that oil into heat for warming the rooms of the house. The remainder will be lost.

Other desired functions in buildings that require energy inputs include space cooling, mechanical ventilation, lighting, supplying domestic hot and cold water and running various

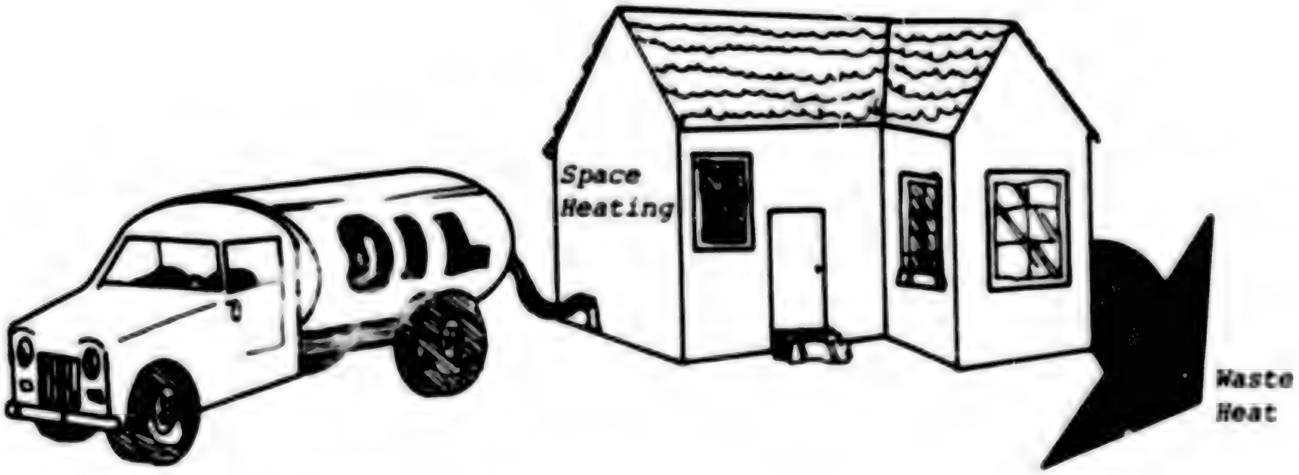


Figure 1 *Flow Diagram*

appliances and pieces of equipment. Figure 2 shows the components of energy demand for all residential and commercial buildings in the U.S. in 1970.

Energy resources used by buildings to provide these desired functions include electricity, natural gas, propane, No. 2 and No. 6 fuel oil, coal, wood, solid waste, solar, wind, hydropower, and heat from people. Some of these are supplied commercially and paid for as part of the site energy budget. But the "free" energy provided directly from sun and wind is also important, as is the heat generated by people within the building.

All of the building's components or subsystems affect the way it consumes these various energy inputs. Improving the efficiency of the components or the way they are used can offer major energy savings. In fact, these are the two big ways to conserve: changing the building and its components or changing the way the building is used.

Areas of the building where opportunities to conserve may be found are:

- use of interior space
- infiltration
- transmission
- ventilation
- lighting
- hot and cold water
- heating and cooling systems
- electric power.

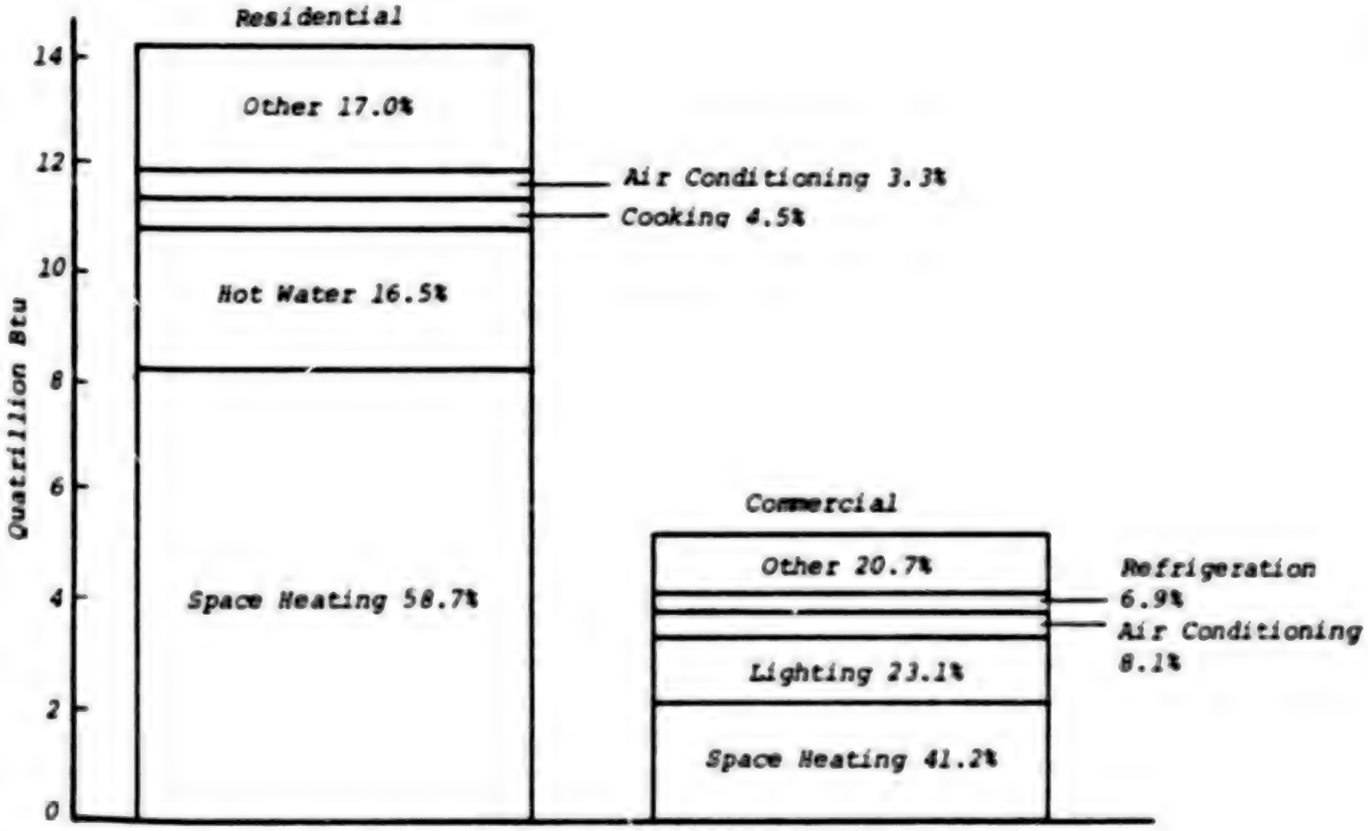


Figure 2 *Components of Demand (1970)*
(Source: Federal Energy Administration)

BUILDINGS

The following discussion will introduce you to the kinds of problems that face you in each of these areas. It is intended to provide a first look at the ways your buildings may be wasting energy, to help you as you begin to look for potential savings. The conservation measures in this section are divided according to the problem areas just listed that exist in most buildings.

As you become more fully acquainted with energy waste in buildings, and the potential for savings, you will require more detailed and technical knowledge of methods and techniques for realizing savings, and for analyzing the energy and cost impacts of implementing conservation measures. In some cases, you will require the assistance of a qualified and experienced professional. At the end of this preliminary section on buildings, we give you a brief introduction to the technical reference material on energy conservation in buildings, and describe how you can best use it to answer questions that will come up during the planning process. We also suggest some ways to know when the reference material will not be enough to solve your problem, requiring you to call for professional assistance.

PROBLEM AREAS-OPPORTUNITIES FOR ENERGY CONSERVATION

The measures selected for presentation here deal with methods for saving energy during the second stage of a building's life cycle: its operation during useful life. However, the opportunities for energy conservation at the beginning of the life cycle, during the design and construction phase, are considerable, and can substantially reduce the need to save energy after construction has been completed. Studies, reference works and additional articles included in the reference materials will be of use to anyone who may be having a building designed or constructed.

But because energy use in existing buildings represents a major component of energy use at most sites, the planning process for buildings is built around measures for saving energy in existing structures.

Use of Interior Space

The way that occupants use interior building space can have a pronounced effect on energy consumption. During your examination of the building, note the work schedules and shifts of the people working there and look for space that is not used. Check on the closeness of work spaces to uninsulated walls and floors. Note the location of heat producing equipment, such as copying machines, and group them together, away from people in the work area. Make sure that air supply and return grilles and registers are located where they can operate with maximum efficiency. Close down unused portions of buildings whenever possible.

Infiltration

Outside air infiltrates a building through openings, such as windows, doors and cracks. Since outdoor air must be heated or cooled (and sometimes humidified and/or dehumidified) to meet desired indoor conditions, infiltration imposes a significant load on the heating and cooling system. This increases energy use.

Complaints of drafts from building occupants is a good sign that too much outside air is infiltrating into the building.

Check for cracked, broken or missing window panes. Examine doors and windows for weather-stripping and caulking, and to see whether they are properly aligned, since infiltration can occur between the door or window and its frame. As a test, a lighted match held near window and door frames should not flicker on a windy day. In some places, it may be useful to provide automatic door closers, and to instruct those who use the building frequently about proper operation of doors and windows.

Gaps, cracks, and small openings in the building's exterior surface may also cause infiltration losses. Check outside joints, such as those between wall and foundation, or between wall panels. Openings cut for piping, electrical conduits, and air-conditioning systems should be examined.

Transmission

Energy losses may be caused by transmission of heat through the building structure. The amount of heat lost this way and the rate at which it is lost depend upon several factors, including:

- the difference between indoor and outdoor temperatures;
- mass, color and insulating values of the exterior walls, roof, windows and floors;
- wind and sun striking the building exterior.

Note that the same factors that cause heat loss may allow for solar heat gain. While adding to cooling requirements, solar gain can help to reduce heating loads.

Several points to look for in examining a building for transmission losses are noted below, in the areas of insulation, glazing, etc.

In examining the building, check to see:

- whether roof or ceiling insulation has been added, and whether it is undamaged and correctly installed;
- whether floors adjoining unheated spaces have been insulated;
- whether insulation has been installed in exterior walls. If not, note whether this would involve major structural changes.

Although windows transmit heat easily, this type of heat loss can often be controlled at less expense than controlling transmission through walls or ceilings. Look for window shading devices, such as drapes, blinds, or other material which could be used to control heat flows. Does the window receive substantial direct sunlight or reflected sunlight? Do all the windows have storm windows? Do any of the windows have double or triple glazing, or reflective or absorptive coatings on the exterior?

Where conditions of climate and temperature are extreme and transmission represents a major portion of a building's heating and/or cooling load, it may be feasible to undertake special modification projects to reduce transmission or benefit from the extreme conditions. Windbreaks, solar shading devices, roof spray systems, and special screens or overhangs may be used to improve energy efficiency, if they prove to be cost-effective.

Ventilation

The air inside of buildings is changed through ventilation. Because each cubic foot of air drawn into the building must be heated or cooled, altering the rate of air change or ventilation can have a significant impact on energy use. Some building codes demand more ventilation than is necessary to provide for the safety and comfort of building occupants. Many buildings even exceed code requirements, making matters still worse. There have been many changes over the past several years to reduce ventilation rates. Equipment can be adjusted rather easily so that fewer cubic feet per minute (CFM) are circulated through a building or certain rooms in a building. Before making any adjustments, check with your code office to determine if any code changes have been made recently or are in the works.

In your examination of the building, note the operating schedules for ventilation equipment. Check to see whether the system has outside air dampers, and whether they are in good condition. Does the ventilation system have a control system that will turn the equipment completely off if the building is not occupied? Another area where ventilation is important, but sometimes overused, is in toilet facilities. Examine volume settings for toilet exhausts. Check to see whether the exhaust system could be connected to the lights.

Special conditions may call for modifications to increase the efficiency of ventilation systems. For instance, in areas with strong winds, it may be feasible to install baffles that will prevent wind from affecting outdoor air intakes. In large buildings, where more than 10,000 CFM is involved, heat recovery devices and equipment for using outside air for internal cooling (such as economizers and enthalpy controls) may be warranted.

Lighting

In buildings where the lighting system was not designed with energy considerations in mind, savings may be available in several areas. To modify the amount of energy used in lighting, you will need to know how and when the building is used, and what kind and levels of lighting the occupants are accustomed to. You will also need to know the types of fixtures and lamps now in use, and whether there is a maintenance program for them in place.

As you examine the building, check the following items. Note spaces or areas near windows and other sources of natural lighting that are not now being used. Check to see whether lamps and lighting fixtures are free of dust. Are the lighting levels in halls and corridors as high as lighting in rooms where tasks are performed? Can lighting in these rooms be task-related under separate controls, so that energy will not be used to light areas where no work is being performed? Will the luminaires and fixtures accept newer types of high-efficiency lighting equipment?

Installation and controls for lighting systems are also important. Since space usage in a building usually changes several times over the life of the structure, it is useful to allow some flexibility when making modifications to existing systems or installing new ones. Check to see if plans for your building call for changes in space usage. Note whether lighting for the whole building, or large areas of the building, is on a single switch or control and whether it is possible to control individually the level of illumination. Lighting can be controlled automatically, with devices such as timers and photocell systems, and you should note possible applications for such devices.

Usage patterns are especially important to consider when changing the lighting system. Know as much as possible about safety and security needs in the building. Are there long periods when the building is unoccupied, but remains lighted? Are there periods on weekends or in the evenings when the entire building is lighted for maintenance or for limited staff activities? These can have an effect on the energy load.

Hot and Cold Water

The percentage of a building's overall energy use that can be attributed to heating domestic hot water is between 2 and 4% in normal situations. This percentage may be considerably greater in hatcheries and other places where there may be a heavy demand for hot water. Because reducing the amount of water use can result in significant energy savings, a separate section of the Planning Guide is devoted to water conservation. Important savings are also available through reducing the portion of the total building load for hot water heating and reducing losses in the heating and distribution system.

As you examine your buildings for savings opportunities, check to see whether tap water is too hot for direct use and must be mixed with large quantities of cold water. Of course, mixing is normal, but in some situations, water supplied to the tap is too hot when water heater thermostats are set too high. Estimate overall demand for hot water according to season, since drawing water from boilers in the summer may result in poor operating efficiencies. Are there places that use hot water intensively, where a local heat booster could be installed to permit the central system to operate at lower temperatures?

Examine water heaters and the distribution system for leaks and places where the heater itself, storage tanks, or distribution pipes may not be insulated. Check for places where insulation could be effectively increased. The pumps are another potential source of energy waste, and should be checked as part of your inspection of the energy use of the electrical equipment in your building.

Heating of domestic hot water is a promising area for applications of renewable energy technologies, particularly solar thermal systems. You may want to investigate such an application (see Volume II, On-Site Generation, for a discussion of solar thermal technologies). At a minimum, check to see whether your system uses an electric hot water heater. In many instances, electric heaters can be replaced with systems fired by natural gas, coal or oil, improving overall efficiency.

Heating and Cooling

Heating and cooling usually account for the largest portion of energy use in a building. However, heating, ventilating and air-conditioning (HVAC) systems have often been designed and maintained without thorough consideration of fuel costs.

They can be oversized and inefficient and offer many opportunities for improvement.

It will be helpful to you and to any specialists you consult if you know several things about your systems: 1) the type of equipment in the building; 2) the rating of each piece of equipment, in kilowatts (kW), Btu per hour, or total horsepower; 3) the schedule of operation in terms of hours per day, days per week, and weeks per year; and 4) other pertinent information that could help you prepare an operating profile of the system.

Equipment

Mechanical equipment can be broadly divided into eight categories:

- boilers or furnaces used for space heating
- compressors or chillers used for space cooling
- room air-conditioners or through-the-wall units
- ventilating systems
- heat pumps
- pumps
- fans
- miscellaneous.

Depending on the desired functions to be performed by the building, the equipment can be designed, redesigned, and operated in many ways. Within each of these categories there are different types of units. For instance, HVAC systems may be single zone, terminal reheat, variable volume, induction, dual duct, and/or multizone (See Glossary). In your examination of the building, you should note the different pieces of equipment, and how they have been combined into a system. Drawings and plans for the facility will give more precise information which will be useful in considering conservation measures.

Ratings

Each piece of mechanical equipment is designed to operate at a specific capacity, usually measured in terms of power. For instance, furnaces are rated according to Btu per hour; electric drive compressors are usually rated according to total motor hoursepower; and room air-conditioners are rated by Btu or kilowatts. HVAC systems, pumps and fans are often rated according to total connected horsepower. This is true for components of a system, too, such as the condenser pumps and cooling towers of a central air-conditioning system.

These ratings are like the ones we use to rate automobile engines: a 300 horsepower engine is substantially more powerful than a 50 horsepower engine. The same is true of a building's mechanical system. In evaluating building performance, it will help you greatly to find the ratings for each piece of equipment from your records, or from the information recorded on the nameplate or faceplate of the unit by the manufacturer. Frequently, equipment is much larger than necessary to perform its job. If you gather information on equipment ratings, engineers will be able to determine if it is properly sized.

Operation

The primary energy conversion equipment in your building is only using energy when it's in operation, so it's important to know the operating schedule. Don't assume that it's the same as normal working hours: many people have been surprised to find that the mechanical systems are operating hours before people arrive in the morning and long after they leave at night. This can make a big difference in total energy consumption. As you match demand for a desired function with actual energy use, this may be one area where big savings are possible.

Other Information

Other kinds of information will also be important depending on the type of unit you are examining. To indicate performance characteristics, some types of equipment are rated by measures other than Btu/hr, kW or total connected horsepower. Just as a 300 horsepower engine might also be described as a 404 cubic inch V-8, so an HVAC system is described according to the number of CFM per air handling unit and the static pressure of the system; and a boiler or furnace is measured by peak load combustion efficiency. Knowing these characteristics can help you to make an evaluation of the system's energy efficiency.

When you have a profile of the energy-using characteristics of the building's mechanical system, there are several types of modifications to consider. First, operating practices in the building can be modified so that equipment can be operated to meet more closely occupants' needs, without providing excess heating or cooling. Second, a good maintenance program for equipment and systems helps to ensure efficient operation and to prolong the usable life of mechanical equipment. Maintenance checks should be regularly scheduled. This will give you a check on the effectiveness of your program and updated information on the condition of the equipment. Third, modifications of the ductwork, piping, fittings and other parts of the distribution system carrying the heating or cooling medium - water, steam or air - can give quick and relatively large improvements in system efficiency. For example, repairing air leaks in the ductwork of a forced-air system, a relatively simple operation, can substantially reduce waste. Fourth, the controls of your system may have been inadequately designed, installed or maintained. Adjustment and modification of controls can make them more sensitive and responsive to actual requirements so that energy isn't used if it's not needed.

Finally, the overall system may be improved by such measures as resizing and modifying existing equipment. These measures should ideally be performed by qualified personnel in accordance with ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) procedures. When making major adjustments, many factors must be considered. For instance, improving the efficiency of one component may improve the efficiency of the overall system, but this is not always the case. Modification of the exhaust system of a ventilating unit, for example, so that less air is removed from a building may mean fewer air changes and less demand for space heating. In a colder climate this might be fine. In a warmer climate, however, reduced ventilation could also mean warmer temperatures inside the building and greater demand for space cooling, thereby increasing overall energy consumption. Alterations of this kind often demand a precise analysis by a qualified professional.

Electric Power

Consumption of electric power can be a major element of energy use in buildings. An analysis of use patterns, coupled with an examination of the building's electric system, can yield many options for energy savings.

In larger buildings, or in areas where many large motors are operated, there may be a power factor problem. Power factor is an indication of how effectively electricity is used at a site. The easiest way to tell if you have a power factor problem is to examine the electric bill for your site. If you find a charge on the bill labeled "Power factor penalty," then you probably have a problem, and you will need professional assistance to perform a power factor survey. In a power factor survey, an engineer will come to your site and study your electrical system to find the cause of your power factor problem and recommend a solution. Electrical utility companies will frequently provide this service at a very low cost.

Another potential problem in buildings' electrical systems is undersized wiring. This is not only an energy problem but also a possible safety hazard. Some signs that you may have undersized electrical wiring are: lights that flicker or dim when motors are turned on; motors that get very hot when they run; fuses or circuit breakers frequently "blowing;" and electrical panel boxes (where the fuses or circuit breakers are) that are warm to the touch. If you suspect that you have undersized electrical wiring, a qualified electrician should be contacted.

A review of present maintenance and operating practices will be helpful. For example, atmospheric conditions can seriously affect the efficiency of electric equipment, but can be mitigated by appropriate maintenance procedures. Water, dust, excessive heat or cold, humidity, dryness, corrosion and vibration can reduce performance and affect usable life. High humidity can cause dirt build-up on parts, reducing efficiency. Are equipment rooms dry and adequately ventilated? If transformers or switchgear are located outdoors, do they have adequate shading to prevent heat build-up, and are they adequately ventilated by natural means?

Information on the times when electrical equipment is used is essential. There may be periods when some items can be disconnected or switched off, such as vending machines operating in a building that is closed and locked on weekends. Transformers for heating equipment may be de-energized through the cooling season.

Many utilities include a "demand" charge in their rates. This charge is different from the charge for actual amount of electrical energy used, or kWh. Demand is the rate at which electric energy is delivered. It is an indication of the maximum rate at which power will be drawn from the utility. High demand results from simultaneous operation of several different pieces of equipment. Demand charges can reach 30 to 35% of the total bill. If your electric bill contains a large charge for electric demand, or if "billing demand" on the bill is higher than "actual demand," a careful analysis of usage patterns and demand peaks may be warranted. (See Data Form 1, "Electricity," p. 24, in the "Planning Process" section for a more detailed explanation of the "demand" concept.)

USING THE REFERENCE MATERIALS IN THE PLANNING PROCESS

Reference materials have been provided with these planning documents to expand the amount of technical information available to you. If you can put the information to use, you will begin to develop solutions to a wide variety of problems on your own. At times, however, you will find the process frustrating, especially if the problem you're confronting requires a sophisticated engineering solution. Do not be discouraged - it is not realistic to assume that everyone will be able to complete every part of every problem entirely on his own. There are a number of measures listed in the "Planning Process" section for which you will probably require some form of technical assistance. You will need to draw on the expertise of a builder, an engineer, or other specialist, to help you develop a solution, perform a cost benefit analysis for a complex measure, or in some cases, assist you in determining whether a certain measure is applicable to your situation.

How to Use the Reference Materials

The following discussion outlines, according to the type of measure you are dealing with, what you can expect to accomplish on your own, what you should leave to the expertise of a professional, and when you may wish to work with a technical consultant on a "pet project" which may have energy conserving implications. Examples are given to help you know when you need to look for assistance.

Many of the conservation measures listed are simple enough for you to work through entirely on your own by using the reference materials provided. For example, if you wish to add storm windows, you would go to measure 1.11 "reduce transmission heat loss through openings such as windows, skylights..." where the reference given for residential buildings is In the Bank...Or Up the Chimney? For this type of measure where the reference material is self-explanatory, you should do all of the work on your own.

A second group of measures, however, may require technical assistance to:

- determine applicability
- compute savings
- prepare an adequate description of the measure in order to get bids.

A good example of this type of measure is 1.9 "Improve burner/boiler efficiency." Again, for residential buildings, the reference given is In the Bank...Or Up the Chimney? The reference describes the options available to the homeowner and outlines what is involved in a complete oil burner check-up and a furnace efficiency test. The reference does not give the reader instructions on how to service the burner, or how to take stack temperatures and CO_2 readings to determine furnace efficiency and compute potential savings. It is clear here that the lay-person must seek the advice of a professional. (However, if the reader is an operations manager for a larger building, a checklist similar to that mentioned in the reference may be all that is necessary to give to the O & M crew to incorporate

There is a third category of measures which are not listed at all in the "Planning Process" section because their application is specific to an individual need, climatic variation, etc., but for which the reference section can be helpful. For example, most passive solar retrofit applications would fall into this category. A few examples are: attaching a greenhouse to a heated structure, adding windscreens or sunscreens to a building's exterior, redesigning the interior of a building under renovation, or sectioning off rooms to create thermal barriers (like locating storage space on the north side of a building or adding a vestibule). All are measures which affect the heating requirements as well as the comfort of your building. The extent to which these changes affect your fuel bill, however, is difficult to calculate. Consulting a professional could provide you with this information as well as ensure that your design is energy efficient.

The technical reference material can be particularly useful to you in researching projects of this nature. For instance, if you want to build a greenhouse, the reference material on new buildings will allow you to identify potentially suitable physical designs and alternative energy sources. You should be able to get a solid understanding of the material from these sources; and in some cases, you may decide to go ahead with the design and construction of a particular project, such as building a solar window box. However, the literature will not direct you to a method of computing costs and savings. Here again, you must consult a professional engineer or architect.

How the Reference Materials are Organized

Technical reference materials are divided into core and secondary sources. The core sources are those books which comprise your "Buildings" library and have been referenced in the "Planning Process" section. These publications contain information that will be helpful in analyzing and implementing the measures listed there. While the secondary publications are not provided in the library, they do contain valuable information and may be useful in solving specific problems.

Core publications have been selected to give you the best available references in several important areas.

The majority of the specific references for buildings are contained in three books. They are:

1. Guidelines for Saving Energy in Existing Buildings - Building Owners and Operators Manual (ECM 1)

2. Guidelines for Saving Energy in Existing Buildings - Engineers, Architects, and Operators Manual (ECM 2)

3. Energy Survey Manual

The first two, commonly known as ECM 1 and ECM 2, contain much of the "hard" information about energy-saving measures in buildings. Here are many of the detailed descriptions of measures, as well as the greatest number of procedures and information for calculating costs and benefits. The only other places in the reference materials where a significant amount of specific cost/benefit information can be found are in Fuel Savers, which is the handbook on passive solar retrofit the handbook on passive solar retrofit ideas; and In the Bank...or Up the Chimney?, which contains much of the cost/benefit information on residential retrofit construction. The third major publication, the Energy Survey Manual, is best for the overview it provides of the formal technique of surveying a relatively large building. This publication emphasizes mechanical systems in its consideration of energy-saving measures.

The first three books mentioned above do not consider implementation of renewable energy resource technologies. Several publications - including Fuel Savers and Passive Design Ideas for the Energy Conscious Architect - are included to present passive solar options that can be viewed as measures for displacing conventional fuels with energy from a renewable source, the sun. Other measures which displace non-renewable energy sources, such as active solar and wind generation techniques, are treated in Volume II, On-Site Generation.

Two publications deal solely with residential energy conservation. These are In the Bank...Or Up the Chimney?, and the Time-Life Weatherproofing book. Whereas In the Bank contains much information on cost/benefit and some good sections on how-to-do-it, the weatherproofing book is entirely implementation oriented.

The remaining literature consists of books which give instructions for making new buildings energy efficient beginning at the design stage; and books dealing with special problems or building types. The best reference of the first type is the American Institute of Architects' very readable book, Energy Conservation in Building Design. Information on new design has been included not because it particularly relates to your own planning process, but because it can help you with the design and construction of simple structures, as well as in working with architects, planners, and engineers in the design of more complicated facilities for your site.

Mobile homes, historic structures or older buildings, and food service/retail store operations present special problems in taking energy conservation action. For this reason, we have included the best publication in each of these areas. Ways to improve the energy efficiency of windows and their components are presented in Window Design Strategies. Outdoor lighting also presents special problems, so we included Energy Management in Municipal Street Lighting. These do not replace the first three publications discussed above, but they will help deal with technical concerns in these areas. Since landscaping can directly and indirectly affect energy consumption in buildings, two publications cover this subject area. Plant a Tree matches deciduous and coniferous trees to climatic zones, while Landscape Planning for Energy Conservation suggests a number of different methods to minimize the effect of the wind and to increase and decrease solar heat gain through landscaping.

PLANNING PROCESS

Now that you are familiar with the concept of buildings as energy-using systems, and are aware of the areas where waste is likely to occur, it is time to work out your own site specific program for making your buildings energy efficient.

Energy conservation in buildings can be achieved through a wide variety of measures. These opportunities to save energy and reduce building operating costs fall into four basic areas:

- proper operation and maintenance
- upgrading and modifying existing building components
- eliminating or replacing buildings
- drastically reducing consumption in new buildings through advances in design and technology.

The process for collecting data about your buildings, analyzing the data, and then using that information to evaluate conservation measures involves more steps than other similar sections in the Planning Guide. However, the final results of your efforts will be a very valuable contribution to energy conservation in your refuge or hatchery. Although the process may appear complicated, it will become easier and quicker with each building you examine as you sharpen your intuition and knowledge. This process relies a great deal on what you already know or can learn rapidly about how your buildings use and waste energy. It recognizes, however, that in some instances you will need outside technical assistance. Be honest with yourself in these cases, and contact appropriate local resources, the Denver Engineering Center, or your Regional Energy Coordinator.

The process for selecting the best conservation measures for your buildings involves 9 steps. The diagram on the next page shows this step-by-step process along with the data forms involved -- the Energy Management Form, and the Measures Assessment Form. A detailed discussion of each step follows.

Step 1. Familiarize yourself with the information in the preceding pages on energy conservation in buildings.

If you have not already read this section, you should do so before continuing. It will provide crucial definitions and a better understanding of how buildings use and waste energy.

Step 2. Enter initial data on all of your buildings from the DOI "Preliminary Energy Audit" on Data Form 1, the Energy Management Form.

The Energy Management Form (EMF)* serves several purposes in the planning process:

- It enables you to compare the relative efficiencies of similar buildings using the Energy Utilization Index (EUI).
- It allows you to compare consumption of various fuels to indicate potential areas of energy waste within the building.

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*This form was developed by the National Electrical Manufacturers Association and the National Electrical Contractors Association for FEA, U.S. Department of Commerce, National Technical Information Service #PB254683, "Total Energy Management: A Practical Handbook on Energy Conservation and Management," 1976.

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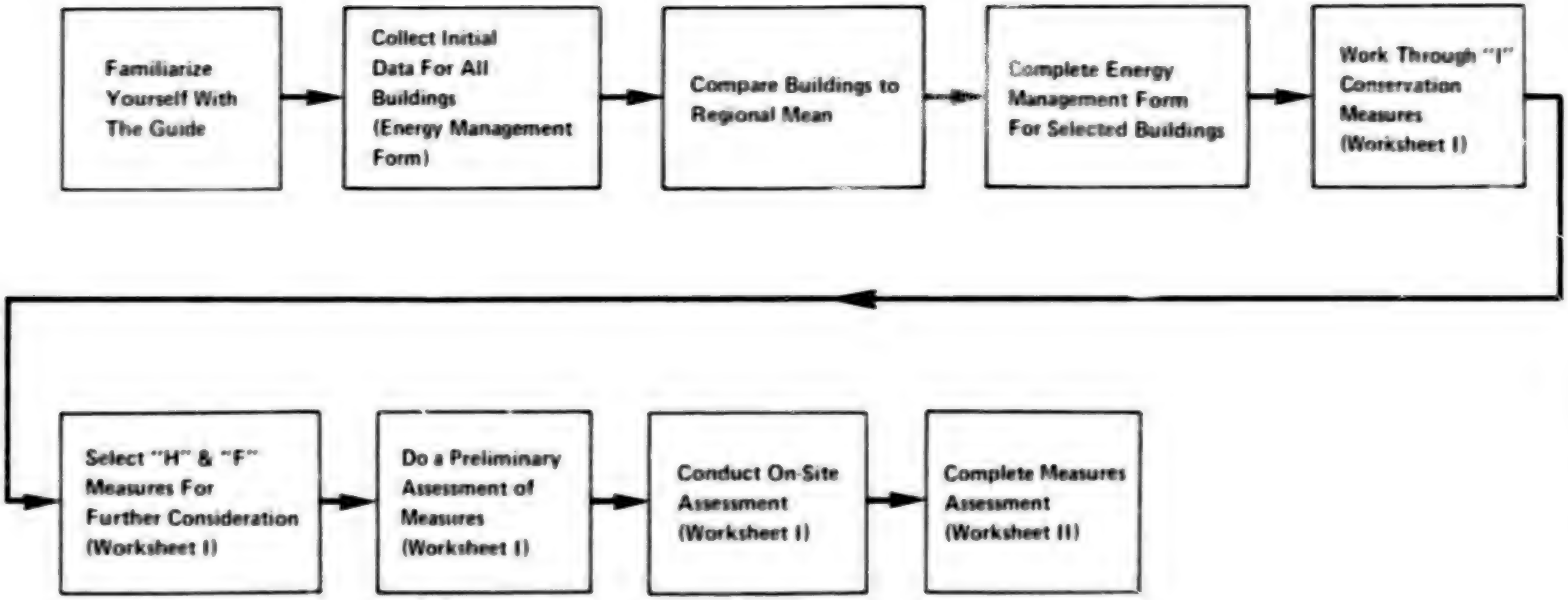
Page

Buildings Planning Process Summary


Familiarize Yourself With The Guide
Collect Initial Data For All Buildings (Energy Management Form)
Compare Buildings to Regional Mean
Complete Energy Management Form For Selected Buildings
Work Through "I" Conservation Measures (Worksheet I)
Select "H" & "F" Measures For Further Consideration (Worksheet I)
Do a Preliminary Assessment of Measures (Worksheet I)
Conduct On-Site Assessment (Worksheet I)
Complete Measures Assessment (Worksheet II)

- If you use the EMF as a monitoring device and keep records over several years, it enables you to spot quickly changes in building efficiency over time. This can be very valuable information in targeting your conservation efforts.

In addition to the above services that can be performed using the EMF in the planning process, it can also be used for fiscal management. It enables your site to determine whether a particular building is being billed correctly for fuel, whether it is receiving the lowest possible rates, and to project energy costs in the future.

The EMF is divided into two sections. The top contains detailed data on fuel consumption and will only be filled out for those buildings that are selected as targets. The bottom section contains overview information of the building. This should be available from the DOI "Preliminary Energy Audit," which has already been completed for your site and which should be on file. This section should be filled out for all of your buildings so that you will have an accurate basis on which to select target buildings.

Perhaps the most important piece of information you will get from filling out the EMF is the Energy Utilization Index (EUI). The EUI is the number of Btu consumed per gross square foot of conditioned space (heated or cooled) per year. Generally, the higher the EUI, the less efficient the building. The EUI is a standard which allows you to compare buildings of different sizes and with different fuel consumption patterns, just as we use miles per gallon to judge the relative efficiency of different sizes and models of vehicles.

The Energy Management Form and detailed instructions for filling it out are given in Data Form 1, p. 22.

Step 3. Compare the EUI of your buildings to the regional mean EUI for similar types of buildings to determine those which you should focus your attention upon.

Table 1 shows the categories of buildings that you should use for performing the analysis required in this step. The idea behind this categorization is to group buildings of a similar function together so that they can be compared. You would expect that the amount of energy used in office buildings is very different from the amount used in residences, and it is. But by comparing office buildings, you can quickly spot which are the energy wasters. Once you have categorized your buildings, you will be able to compare them with similar buildings. In other words, are your buildings' EUI's "high" or "low"? There is no set of EUI standards specifically designed yet for refuge or hatchery buildings to help you answer this question. However, there is a guideline available now that lists the mean, or average, EUI for building categories in your climate region. These are presented in Table 2.

You have already sorted your buildings by category. But before you can use this table, you must also know what climate region you are in. There are wide variations in the effect of temperature and weather on the energy requirements of buildings. Research has shown that heating requirements vary directly with the difference between 65° F and the daily mean

Table 1 Building Categories

Category	Examples
• Warehouses	Operations, maintenance, garages, fish hatcheries, firewatch towers, utility buildings
• Offices	
• Assembly	Visitor centers, lecture/classroom, auditoriums, theaters, galleries/exhibits/museums
• Restaurants	Cafeterias, full-service dining rooms, fast-food outlet, coffee shop/snack counter
• Residential/nonhouse-keeping	Hotels, motels, lodges, dormitories
• Mobile Homes	
• Single Family Detached	
• Single Family Attached	Townhouses
• Multifamily Low-rise	Cluster homes, garden apartments.

outdoor temperature.* Cooling requirements show a similar, but not as precise, variation. From these findings the concepts of "Heating Degree Days" (HDD) and "Cooling Degree Days" (CDD) (the difference between the mean outdoor temperature and 65°) were developed (See Data Form 1, p. 23). For example, if the mean outdoor temperature were 50° on a given day, that would contain 15 Heating Degree Days (65° - 50° = 15). The Degree Day total for the year gives an estimate of the severity of climate for heating and cooling purposes. Thus, just as "building category," Heating and Cooling Degree Days can serve as "equalizers" in comparing buildings. You would not expect similar buildings in Maine and Florida to have equal EUI's.

You can obtain information on your site's total annual Degree Days Heating and Degree Days Cooling from

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*This explanation of climate regions is taken from Total Energy Management, p. 8.

Table 2. Mean Value of Annual Energy Performance in 1000s Btu/sq. ft. for Building Categories and Climate Regions

Area Bldg. Type	NAT'L	REGION 1	REGION 2	REGION 3	REGION 4	REGION 5	REGION 6	REGION 7
Restaurant	159	162	178	186	144	123	137	137
Residential/Nonhousekeeping	95	99	84	94	125	90	93	106
Mobile Homes	75	103	84	81	67	42	54	70
Single Family Detached	69	104	73	61	52	43	38	58
Warehouse (Operation/ Maintenance)	65	75	82	65	50	36	37	39
Office	64	65	76	65	61	51	50	64
Assembly	61	58	76	66	51	44	68	57
Single Family Attached	47	65	54	45	37	35	33	45
High-Rise Apartments	49	53	53	52	53	34	29	*
Multifamily Low-Rise	43	58	55	41	31	27	22	32

the Weather Bureau, your local electric or gas utility, or your local oil distributor. Then determine which region applies in your area. (See information above.)

Once you know in which HDD/CDD Region your refuge or hatchery is located, turn to Table 2 and find the column for your region. Listed in that column are the mean Btu per square foot for the building category listed at the left. Compare the EUI's for your building with the means listed in the table.

For each category of buildings in your refuge or hatchery, find your regional mean. Don't be too discouraged if few or even none of your buildings are at or above the mean. The mean values in the table were developed by architects and engineers based on new buildings being designed

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*data not available

Information from "Final Report, Phase One/Base Data for the Development of Energy Performance Standards for New Buiildings" by A.I.A. Research Corp., Contract H-2689, U.S. Department of Housing and Urban Development in cooperation with U.S. Department of Energy. Figure ES-4.

Heating Region I	Less than 2,000 CDD; more than 7,000 HDD
Heating Region II	Less than 2,000 CDD; more than 5,500 to 7,000 HDD
Heating Region III	Less than 2,000 CDD; 4,000 to 5,500 HDD
Heating Region IV	Less than 2,000 CDD; 2,000 to 4,000 HDD
Heating Region V	Less than 2,000 CDD; 0 to 2,000 HDD
Heating Region VI	More than 2,000 CDD; 0 to 2,000 HDD
Heating Region VII	More than 2,000 CDD; 2,000 to 4,000 HDD

today. Since new buildings are likely to have incorporated energy saving design features, your buildings will probably be much less efficient. When more applicable figures are developed, or when regional FWS data are available, those standards should be substituted for Table 2. You should now know which buildings you want to focus your attention upon when you work through and evaluate conservation measures for your buildings.

Step 4. Complete Data Form 1, the Energy Management Form.

In Step 2, you filled out the bottom portion of the Energy Management Form. You should fill in the top portion of the EMF for those buildings which you feel need special attention. This will help you to check the performance of the building as you implement energy conservation measures.

Detailed instructions for completing the EMF are included with Data Form 1.

Step 5. Work through the "I" Measures on Worksheets I for each building.

Buildings measures are separated into three overall groups: those designated "I" for "immediate priority," "H" for "high priority" and "F" for "further study." The "I" measures, as the first category has been called, should be considered for all of your buildings. Little or no data collection will be required for assessing these measures and working them through the Worksheets II, Measures Evaluation.

The process of taking "I" measures through the Measures Evaluation can be streamlined to help you complete them quickly. Four of the 10 columns on the planning process may be omitted, unless you find a need to write in them. These four columns are:

- potential benefits
- first checkpoint
- savings
- payback period.

For many "I" measures, it is difficult to figure savings. But most involve little or no cost, so payback can be assumed to be almost immediate. Motivation and incentives play a large role in implementing many of these measures; thus, getting people in a building involved and committed to conserving energy will be a major consideration. For this reason, it is suggested that you work with representatives from the building. Both building users and maintenance staff should be included in your decision-making process. You will complete Worksheets II just as in other sections.

Step 6. Using information from the Energy Management Form and what you already know about your buildings, select other measures from the "H" and "F" groups and check (✓) them for further consideration on Worksheets I, Potential Building Measures.

After you have completed working through the "I" measures, you should continue the process of selecting conservation measures for your buildings. To do this you must ask: "why is this building using too much energy?" In addition to considering how the building is used, the remaining possible answers fall into these categories:*

1. Infiltration (including windows, skylights, and doors
2. Transmission (including insulation, glazing, exterior surfaces)
3. Ventilation
4. Lighting
5. Domestic Hot and Cold Water
6. HVAC System Operation
7. HVAC System Maintenance
8. HVAC Control, Adjustment, and Modification
9. Electric Power.

Which of these areas are most responsible for energy waste in the building? To find this out, you need to conduct two major activities.

In the first, you look at numbers, and link energy consumption (electricity, gas, oil) with energy using systems (heating and cooling, lighting, etc.). Your examination of these numbers gives you some idea of the relative inefficiency of various buildings and their energy using systems. You have already compared buildings with each other by ranking them by EUI. Now you should focus on the energy using systems within each target building and try to determine which systems are most responsible for its energy waste. The EMF is the key here. The EMF will give you some indication of how various fuels are used in the building. Unless you have separate metering** for different end uses, you will not be able to allocate fuels precisely to energy using systems - your electricity consumption may contain cooling, lighting, power equipment, and even heating in some cases. If heating is not included, you can roughly separate cooling from other electricity uses by comparing your usage in summer (cooling) months with that in winter months.

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*Before you begin working, it might be helpful for you to reread the discussions of these areas. See Section C entitled Problem Areas - Opportunities for Energy Conservation."

**In some buildings (usually large office or other commercial buildings), there are Btu or energy consumption meters which record quantities of fuel and power used for specific components of the buildings. If you have this capability, this step will be much simpler. If your current metering capacity does not allow you to allocate quantities of fuel to specific end uses, e.g., heating, hot water, lighting, etc., then you may want to consider a project to upgrade your metering so that greater control over internal building conditions can be achieved and more accurate conservation planning can occur.

The second activity involved in detecting energy waste is a careful on-site assessment of the building. If you suspect that the heating and cooling system is the major problem area, you can identify the real culprit only by going out and looking at the various components of that system - faulty equipment, poor maintenance procedures, uninsulated pipes or ducts, etc. During your Walk-through of the building you may also uncover villains you hadn't even suspected.

Thus, the phrase "detecting energy waste" is not accidental - your task is much like a detective's. First, you make some informed, intelligent guesses about the situation; then you go out and investigate those hunches, gathering physical evidence until you can confidently say that you have identified some, if not all, of the problems.

Once you have made some estimates of problem areas, turn to Worksheets I, Potential Building Measures and place a checkmark (✓) beside those measures which should receive further consideration.

At this point, your hunches do not need to be too specific - you will refine them later during the Walk-through of the building.

Step 7. Do a preliminary assessment of the applicability of energy conservation measures you have checked from what you already know about your building. Record your conclusions on Worksheet I, Measures Assessment Form.

Although the list of potential measures on the Measures Assessment Form may appear somewhat overwhelming, this step is designed to enable you to eliminate a significant number of them without leaving your desk. Using the Measures Assessment Form, you will make a judgment about the current status of each measure. It is a) in place or planned, b) not applicable, or c) a potential activity. If a measure is already in place, planned, or not applicable (because the building does not contain the particular equipment or system), you do not need to consider it any further. Only those measures marked "potential activity" will be examined during the Walk-through. Since you will be eliminating measures at this point, it is important that, if you are not sure about the status of a measure, you call it a "potential activity." Then you can examine its applicability more closely during the Walk-through.

As you go through the measures, you will notice that some are marked with a "T." This symbol indicates that some technical expertise will be required to evaluate the measure accurately. In some cases, people within your refuge or hatchery will have this expertise; in others, you may require outside assistance.

Step 8. Using the results of Step 7, conduct an on-site assessment or Walk-through of the building to check those measures which were initially judged applicable. Record your observations on the Worksheets I, Building Measures.

Beginning with the category of measures you suspect to be the primary contributor to energy waste, now you should gather the physical evidence to support your hunches or to point you in new directions. As you walk through the building, check all measures marked "potential activity" to assess their actual applicability. For example, if the measure reads "replace broken or cracked window panes," look at all of the windows in the building to see if any are broken. If there are broken or cracked panes, check "applicable;" if all windows are intact check "not applicable." With some of the more technical measures, if you do not feel that you have the expertise to make this judgment, check "technical assistance required." Do not try to assess thoroughly the feasibility and desirability of the measures at this point - you will use the Worksheets II for that; simply note whether or not the measure applies to the building and its equipment.

The time required for the Walk-through will depend on four major factors: the size of the building, the number of measures you were able to eliminate during the Preliminary Assessment (Step 7), your familiarity with the Walk-through procedures and the measures, and finally, the expertise and knowledge of your staff. You cannot influence the first factor; the other three will improve with each successive building. Thus, the Walk-through might be very slow for your first building, and detecting energy waste by discovering those areas in the building that need improvement may seem an elusive goal. As you become more familiar with the procedures and the measures, and as you learn more about how buildings use - and waste - energy, your skill in developing hunches and examining physical evidence will improve dramatically.

Step 9. Starting with your "I" measures and continuing with "H" and "F" measures, enter applicable measures and work them through Worksheets II, Measures Evaluation.

You are now ready to work through the Worksheets II. Before you begin this step, it will be helpful for you to review the material which explains how to use the technical references.

Enter each applicable measure, with its number, on the Worksheets. Completing the Worksheets for buildings is very similar to the process used in other sections of the Planning Guide. Any questions you have about the process or definitions of columns should be brought to the attention of your regional or Washington Office energy coordinator.

A sample completed Worksheet II, Measures Evaluation, is included following the Potential Building Measures.

After you have completed a list of potential conservation measures for this section, you should review the material in the Introduction which explains how to pull all of your measures together into a comprehensive Energy Conservation Management Plan.

REMEMBER: The measures you are considering for buildings are meant to be a part of your total plan.

DATA FORM - 1

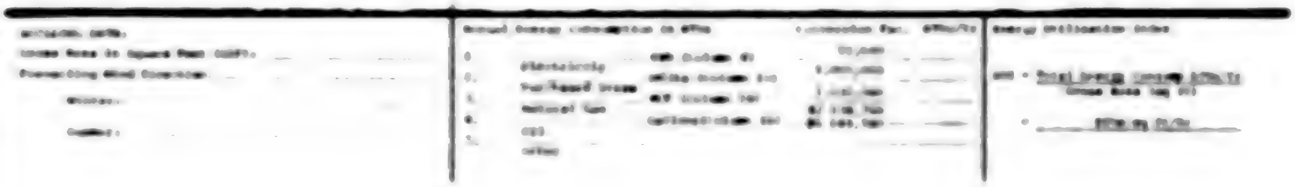
ENERGY MANAGEMENT FORM*

INSTRUCTIONS

The two sections of the Energy Management Form are filled out at two different steps of the planning process for Buildings. First, in Step 2 of the process, you should fill out the bottom portion for all of your buildings. Then in Step 6, you will complete the more detailed top portion for your target buildings.

Instructions for Step 2:

For this step you should fill in all of the information on the bottom portion of the EMF which is reproduced below:



The basic data for this section should be available from your "Preliminary Energy Audit" or from your site's own records. A sample completed EMF follows these instructions.

Building Data: The essential information required here is the gross square footage of the building involved. Gross square footage may be taken from your Preliminary Energy Audit or is easily obtained by measuring inside wall-to-wall distance of each floor including the basement. To determine gross square footage of the building, simply add the gross square footage of conditioned (heated and/or cooled) area on all floors. Make no deductions for storage areas, columns, etc.

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*This form and its instructions were adapted, with minor modification, from Total Energy Management, First Edition, developed for FEA by NEMA and NECA.

[illegible]tinued)

Prevailing Wind [illegible]on: In order to assess various landscaping measures you [illegible] need to know the prevailing wind direction for your site in summer and winter. Usually, the direction is different for these two seasons. If the direction is the same, landscaping for energy conservation becomes more difficult because blocking "chilling" winds of winter frequently blocks "cooling" breezes of summer as well. Local Weather Bureau reports should provide this data.

Btu Conversion: Annual energy consumption is determined easily by multiplying the total annual amount of a given energy form (Columns 4, 10, 16 or 19) by the appropriate conversion factor. This information may be obtained from the Preliminary Energy Audit or your site's records. The result in each case is the Btu equivalent of energy consumed. Add together to determine total Btu consumed for the year.

Energy Utilization Index: Energy utilization index (Btus per gross square foot per year) is determined by dividing total annual energy consumption in Btu consumed by the total gross square footage of the building.

Instructions for Step 6:

For each of your target buildings you should complete the top portion of the EMF. You do not have to use one calendar year for this form - you can use June of one year through May of the following year rather than January through December if you choose. You should note the calendar years if you use the latter method, however, so your analysis of trends will be accurate.

After you establish what period your base year data will cover, the following procedures should be followed in order to complete the form:

Month (Column 1): Regardless of the billing date used by electric, steam, or gas suppliers, energy units consumed should be extracted from the bill for that month in which the greatest number of days occurred. If the billing period is March 2 through April 2, enter the usage under the month of March.

Heating Degree Days/Cooling Degree Days (Columns 2 and 3): Past studies indicate that daily requirements for space heat and fuel/energy consumption vary directly with the difference between 65° F and the outdoor mean daily temperature. The outdoor mean daily temperature is the average of the maximum and minimum outdoor temperature during the 24 hours of a given day. For example, if the maximum temperature during the day is 55° F and the minimum is 35° F, the mean would be 45° F. The heating degree days, therefore, would be 20 (65° F - 45° F). If there are 30 days in the month and each has 20 degree days, total degree days for the month would be 600 (20 x 30). Cooling degree days are determined in the same manner, although it is readily admitted that many other factors such as humidity, solar conditions, and wind play a sig-

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nificant role during the cooling season. Until such time as an accurate index is established, however, cooling degree days will have to suffice.

It should be noted that EUI figures may be calculated for any given month. This may be advisable in order to monitor the effectiveness of implemented conservation measures. Degree days are entered on the form next to the month column, because in this position they provide a basis for comparison. For example, it would be unfair to compare the EUI of January, 1974 with the EUI of January, 1975 if January, 1975 were twice as cold as January, 1974. Information on the number of degree days each month in your area usually can be obtained from your local electric or gas utility, oil distributor, or the U.S. Weather Bureau local climatological reports which are issued monthly and are available for a nominal amount. Normally, heating degree day entries will be made for the months of October through May. Cooling degree days usually include the months of June through September.

Electricity - Kilowatt Hours (kWh) (Column 4): Under this column enter the kilowatt hours shown on the electric utility bill for the appropriate month.

Electricity - Kilowatt Hours Per Degree Day (Column 5): If electricity is used for heating, note the product of dividing kWh for a heating month by the number of heating degree days for that month. If electricity is used for cooling, divide the kWh for each cooling month by the number of cooling degree days. In either case, as efficiency increases, the product decreases.

Electricity - KW Demand - Actual (Column 6) and Billed (Column 7): This column is optional if you are going to use the EMF only for this planning process. Electric charges for larger facilities usually are broken into two major components - the amount of electricity used (kWh) and the rate of electricity used (kWh)over a preselected short period of time, usually 15 to 30 minutes. The greatest level of demand is registered during peak periods, when several major pieces of equipment are operated simultaneously. Charges for the amount of electricity used (in kWh) are based on the cost of generation of electricity. Demand charges reflect the fixed investment which a utility has in the distribution, transmission and generating equipment which must be available to meet your peak demand. In many cases, the actual and billed demands will be different. Actual demand is a record of what your demand really amounted to during the month. Billed demand is the actual demand adjusted by the various rate provisions and is the demand used for the computation of charges. In Philadelphia, for example, demand rate for two rate schedules is billed in accordance with the following provision: "During the eight months of October through May, the billing demand will not be less than 40% of the maximum demand specified in the contract nor less than 70% of the highest billing demand in the preceding months of June through September." Given the way rates are structured, use of the EUI will enable you to establish during which months an effort should be made to reduce

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demand and demand charges. For example, in Philadelphia, highest demand usually is recorded in July or August. If demand during both these months can be reduced, then demand charges for heating months (which cannot be less than "70% of the highest billing demand") will be lowered. Be certain to enter actual and billed demand in the correct columns. Many smaller facilities will not pay a separate demand charge and, accordingly, columns 6 and 7 should be left blank.

Electricity - Cost - Total (Column 8): Enter the total cost of electricity for the appropriate month.

Electricity - Cost - Per Unit (Column 9): Obtain per unit cost by dividing total cost by kWh. This will enable you to compare costs of different months or of different buildings. This provides a possible means for determining if a billing error was made.

Purchased Steam - m (lbs.) (Column 10): Enter total steam consumption (in terms of thousands - m - of pounds) as shown on the bill.

Purchased Steam - m (lbs.) - Degree Days (Column 11): If steam is used for heating and/or cooling, divide quantity of steam by appropriate heating or cooling degree days, as for kWh.

Purchased Steam - lbs./hr. Demand - Actual (Column 12): Enter actual demand as shown on the bill.

Purchased Steam - lbs./hr. Demand - Billed (Column 13): Enter billed demand as shown on the utility bill. The difference between actual and billed demand is essentially similar to the difference involved for electricity.

Purchased Steam - Cost - Total (Column 14): Enter total cost as shown on the bill for the appropriate period involved.

Purchased Steam - Cost - Per Unit (Column 15): Divide total cost by quantity (m lbs.) and enter.

Fuel Oil - Quantity - Gallons (Column 16): Enter the amount of fuel oil actually consumed during the month, which is not necessarily the amount purchased. By knowing how much was on hand at the beginning of the month, how much was added, and how much was left at the end of the month, you will be able to determine the consumption factor.

Fuel Oil - Cost - Total (Column 17): Multiply the per gallon cost shown on the bill by the amount of oil used during the month.

Fuel Oil - Cost - Per Unit (Column 18): Enter the per unit cost shown on the bill.

Other Fuels: Enter as appropriate (in Column 19, 20, or 21): The total monthly amount for each additional form of fuel - such as

(continued)

natural gas or coal - and calculate total cost and per unit cost as described for electricity or oil.

Fuel - Fuel/Degree Day (Column 22): Make the necessary computations (total amount of fuel divided by number of degree days) and enter the result only if one of the "other" fuels is used for heating and/or cooling. Divide quantity of fuel used for heating during a heating month by the number of heating degree days for the month. Divide quantity of fuel used for cooling during a cooling month by the number of cooling days of the month.

Total Energy Cost (Column 23): Add Columns 8, 14, 17 and 20 and enter.

SAMPLE

ENERGY MANAGEMENT FORM

MONTH	HEATING DEGREE DAYS	COOLING DEGREE DAYS	ELECTRICITY						PURCHASED STEAM						FUEL							TOTAL ENERGY COSTS
															OIL			GAS/COAL/OTHER			FUEL DEG. DAYS	
			KWH	KWH/ DEG. DAYS	KW DEMAND		COST		M (lbs)	M(lbs)/ DEGREE DAYS	lbs/hr DEMAND		COST		QUANT (gals)	COST		QUANT.	COST			
					ACTUAL	BILLED	TOTAL	UNIT			ACTUAL	BILLED	TOTAL	UNIT		TOTAL	UNIT		TOTAL	UNIT		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
JAN																						
FEB																						
MARCH																						
1st Quart.																						
APRIL																						
MAY																						
JUNE																						
2nd Quart.																						
JULY																						
AUG																						
SEPT																						
3rd Quart.																						
OCT																						
NOV																						
DEC																						
4th Quart.																						
TOTAL PER YEAR																						

BUILDING DATA:

Gross Area in Square Feet (GSF): ____________

Prevailing Wind Direction: ____________

Winter: ____________

Summer: ____________

Annual Energy Consumption in BTUs		Conversion Fac.	BTUs/Yr
1. ______ Electricity	KWH (Column 4)	11,600	______
2. ______ Purchased Steam	(M)lbs. (Column 10)	1,000,000	______
3. ______ Natural Gas	MCF (Column 19)	1,030,000	______
4. ______ Oil	Gallons (Column 16)	#2 138,700 #6 149,700	______
5. ______ Other		______	______

Energy Utilization Index:

$$EUI = \frac{\text{Total Energy Consump BTUs/Yr}}{\text{Gross Area (sq ft)}}$$

= ______ BTUs/sq ft/Yr

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SAMPLE

ENERGY MANAGEMENT FORM

MONTH	HEATING DEGREE DAYS	COOLING DEGREE DAYS	ELECTRICITY						PURCHASED STEAM						FUEL							TOTAL ENERGY COSTS
			KWH	KWH/ DEG. DAYS	KW DEMAND		COST		M (lbs)	M(lbs)/ DEGREE DAYS	lbs/hr DEMAND		COST		OIL			GAS/COAL/OTHER			FUEL DEG. DAYS	
					ACTUAL	BILLED	TOTAL	UNIT			ACTUAL	BILLED	TOTAL	UNIT	QUANT (gals)	COST		QUANT	COST			
																TOTAL	UNIT		TOTAL	UNIT		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
JAN	896		1,100	1.22			38.50	.035														38.50
FEB	795		1,050	1.32			36.75	.035							2,100	871.50	.415				.84	908.25
MARCH	806		1,156	1.43			40.46	.035														40.46
1st Quart.																						
APRIL	597		978	1.63			34.83	.035														34.23
MAY	412		710	1.72			24.85	.035							1,650	693.00	.420				.72	717.85
JUNE	195		596	3.05			20.86	.035														20.86
2nd Quart.																						
JULY	26		495	17.67			17.32	.035														17.32
AUG	37		508	13.72			20.32	.040														20.32
SEPT	108		610	5.64			24.40	.040														24.40
3rd Quart.																						
OCT	347		685	1.97			27.40	.040														27.40
NOV	594		719	1.21			28.76	.045							1,200	540.00	.450				.91	586.76
DEC	781		805	1.03			32.20	.045														32.20
4th Quart.																						
TOTAL PER YEAR	5,596		9,412	1.68			346.65								4,950	2,104.50					.52	2,468.55

BUILDING DATA:
Gross Area in Square Feet (GSF): 3,900
Prevailing Wind Direction:
Winter: NW
Summer: SE

Annual Energy Consumption in BTUs — Conversion Fac. — BTUs/Yr
1. 9,412 Electricity — KWH (Column 4) — 11,600 — 32.1 x 10^6
2. Purchased Steam — (M)lbs. (Column 10) — 1,000,000
3. Natural Gas — MCF (Column 19) — 1,030,000
4. 4,950 Oil — Gallons (Column 16) — #2 138,700 / #6 149,700 — 686.6 x 10^6
5. Other

Energy Utilization Index
718.7 x 10^6

EUI = Total Energy Consump BTUs/Yr / Gross Area (sq ft) 3,900

= 1.84 x 10^4 BTUs/sq ft/Yr

WORKSHEET I
POTENTIAL BUILDING CONSERVATION MEASURES

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Instructions

Measures: This column lists the operations, maintenance and retrofit options to be considered for your buildings.

Preliminary Assessment: In Step 9, you will conduct an initial assessment of the applicability of the measures listed. This task should be done from your current knowledge of the building and should not require you to leave your meeting room or office. You will decide whether a measure is in place or planned, not applicable, or a potential activity, and check the correct category. Measures which are in place, planned, or not applicable need not be considered any further. Measures should be considered "not applicable" (NA) if the building does not have a particular type of system (under HVAC categories, options are presented for several types of systems, and you should consider only those which the building has) or if the measures apply to equipment not contained in the building (kitchens, large power equipment). If you are not sure about the applicability of a measure, check the potential activity column at this point so you can assess it more accurately during the walk-through.

Walk-through Assessment: In Step 10, you will go out to the building, and check actual applicability of all "potential activities." You will then check the appropriate column - applicable, not applicable, or technical assistance needed. The "T.A. Needed" column is included in case you need help to decide applicability of more technical measures.

Technical Reference: In this column, reference books and page numbers for each measure are given. (In some cases, the reference applies to an entire group of measures.) References to the following books are particularly applicable to residences (single-family detached, single-family attached, multifamily low rise, high-rise apartments (partial), mobile homes, historical building):

- In the Bank and Up the Chimney
- Weatherproofing
- Insulating the Old House.

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference **
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
1. INFILTRATION:							
1.1 Eliminate air leaks around windows and skylights.							
a) Replace broken or cracked window panes. I *							
b) Replace worn or broken weatherstripping. I							In the Bank, pp. 8-9, 34; Weatherproofing, pp. 7-11; ECM-1, pp. 116-122, 168.
c) Install weatherstripping where none exists. I							In the Bank, pp. 8-9, 34; Weatherproofing, pp. 7-11; ECM-1, pp. 116-122, 168.
d) Caulk around window frames if cracks can be seen. I							In the Bank, pp. 8-9, [illegible]; Weatherproofing, pp. 16-19.
e) Replace broken or missing sealing gaskets and cam latches on operable windows. I							
1.2 Eliminate air leaks around doors.							
a) Replace worn or broken weatherstripping. I							In the Bank, pp. 8-9, 36-37; Weatherproofing, pp. 12-15.

* I indicates priority measures which should be considered first.

** These references are part of a core library which should accompany these energy conservation/mgmt. planning materials.

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POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
b) Install weatherstripping where none exists. I							*In the Bank*, pp. 8-9, 36-37; *Weatherproofing*, pp. 12-15.
c) Caulk around door frames if cracks can be seen. I							*In the Bank*, pp 8-9, 32; *Weatherproofing*, pp. 16-19.
d) Install storm doors. M							*Weatherproofing*, p. 105; *In the Bank*, p. 41.
e) Rehang misaligned doors. I							
f) Repair, replace, or install gasketing on garage and other overhead doors. I							*Weatherproofing*, p. 15; *Survey Manual*, p. 18.
1.) Reduce the amount of air that enters the building when doors are open.							
a) Install automatic door closers on all doors leading outside or to unconditioned areas. M							
b) Adjust automatic door closers to permit faster closing. I							
c) Install vestibules at frequently-used entrances. (T)* F							
d) Install revolving doors at frequently-used entrances. (T) F							
e) Install an air curtain. (T) F							

(T) *The technical assistance of an engineer is suggested. * M and F - See following pages.

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
f) Install a card-, key-, or radio frequency-operated garage door which closes automatically. H *							
g) Install garage doors where they are absent. H							
h) Make delivery entrances smaller. F							
i) Use an expandable enclosure for delivery ports which adjusts to meet the back of the truck. H							
1.4 Reduce air leaks around other openings.							
a) Keep fireplace dampers and attic hatchways closed and sealed when not in use. I							
b) Enclose vertical shafts and stairs. H							
c) Caulk around outside water faucets, exhaust ducts, chimneys, telephone or electrical cable entrances, and other breaks in the building's outside surface. I							*In the Bank*, pp. 32-33; *Weatherproofing*, pp. 16-19.
d) Cover or remove all window and through-the-wall cooling units when not in use. I							
1.5 Reduce the impact of summer heat by							*Landscape Planning*, pp. 145-146.

* "*" indicates priority measures which require significant investment but are certain of economic payback.

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Poten- tial Activity	Appli- cable	N/A	Need T.A.	
increasing the cooling effects of wind (An "X" indicates that if prevailing wind direction is the same in summer and winter, the measure may increase the heating bill).							
a) Remove barriers that block breezes such as fences, trees, other vegetation. (X) F							
b) Replace permanent wind barriers with seasonal ones, such as temporary snow fence or deciduous trees. F							
c) Thin or prune trees and shrubs. (X)F							
d) Channel natural breezes using trees, bushes, or structures. (X) F							
1.4 Reduce the impact of winter cold by decreasing the chilling effects of the wind (An "X" indicates that if prevailing wind direction is the same in summer and winter, the measure may increase the cooling bill).							Plant a Tree, pp. [illegible], [illegible]; Landscape Planning, pp. [illegible].
a) Erect permanent windbreaks such as evergreen shrubs, fences, or earth berms. (X) F							
b) Erect seasonal windbreaks such as temporary snow fences or deciduous trees. F							

* F indicates measures requiring further study to determine if they are economically feasible.

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
c) Discontinue pruning of trees and shrubs. (X) F							
d) Dismantle or obstruct wind channels. I							
2. TRANSMISSION:							
2.1 Reduce heat loss in winter and heat gain in summer through windows by improving glazing and using shading devices.							
a) Install light-colored opaque blinds or drapes. H							Building Design, p. 41; ECM-1, pp. 171-173.
b) Add reflective materials to the window side of draperies. H							ECM-1, pp. 171-173.
c) Install thermal barriers on windows for use during unoccupied hours. H							ECM-2, pp. 33-36.
d) Install outdoor sunshades or awnings. H							Weatherproofing, pp. 106-109.
e) Block off and thermally seal all unused windows with opaque or translucent insulating material. H							ECM-2, pp. 33-36.
f) Install storm windows. H							In the Bank, pp. 10, 38-40; Weatherproofing, pp. 98-104.

WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
g) Replace single glazed windows with double- or triple-glazing and/or reflective glazing. F							ECM-2, pp. 25-33; Building Design, pp. 38-39.
h) Add reflective or heat-absorbing film to the inside of existing windows. F							Window Design, pp. 4.1-4.38.
2.2 Reduce heat loss in winter and heat gain in summer through walls, floors, and roofs by adding insulation (and ventilation and vapor barriers where necessary).							
a) Check present insulation and add insulation to exterior walls, and walls which separate conditioned and unconditioned areas. H							In the Bank, pp. 19-20, 42-44, 53; Weatherproofing, pp. 70-77, 86-89; Old House, pp. 10-16, 18-27.
b) Check present insulation and add insulation to top ceiling or attic. H							In the Bank, pp. 19-20, 42-52; Weatherproofing, pp. 70-85; Old House, pp. 10-16, 18-27.
c) Check present insulation and add insulation under floors over garages, crawlspaces, or other unconditioned areas. H							In the Bank, pp. 19-20, 42-44, 54-57; Weatherproofing, pp. 70-77, 90-95; Old House, pp. 10-16, 18-27; Guidebook, pp. 65-67.

WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
d) Check present insulation and add insulation to portions of basement walls that are above ground. H							*In the Bank*, pp. 19-20, 42-44, 58-59.
e) Add roof deck insulation if your building is 20 years old or older, or if you are replacing the roof. H							
2.3 Reduce heat gain in summer through walls and roofs by treating exterior surfaces of the building.							
a) Repaint or clean exterior finish to improve reflective characteristics. I							
b) Repaint or resurface the roof to make it more reflective. I							
c) Install architectural projections such as overhangs for shading. H							*Window Design*, pp. 2.15-2.20.
d) Install roof sprays. (T) F							
2.4 Install passive solar systems to take advantage of solar energy for heating and cooling.							
a) Increase or take advantage of existing thermal mass of the building. (T) F							*Fuel Savers*, pp. 14-15.

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess. In Place Planned	Preliminary Assess. N/A	Preliminary Assess. Potential Activity	Walkthrough Assess. Applicable	Walkthrough Assess. N/A	Walkthrough Assess. Need T.A.	Technical Reference
b) Convert existing or construct new masonry walls for combined collection and storage of solar heat. (T) F							Fuel Savers, pp. 18-19; Passive Design, pp. 29-30.
c) Convert existing roof into solar collector. (T) F							Fuel Savers, pp. 20-21.
d) Add new windows or skylights to increase solar gain. (T) F							ECM-1, p. 171. Fuel Savers, pp. 22-23.
e) Construct small scale window mounted solar collectors. (T) F							Fuel Savers, pp. 26-27; Passive Design, pp. 7.6-7.7.
f) Construct a greenhouse for increased gain in winter and cooling in summer. (T) F							Fuel Savers, pp. 28-31, 42-43; Passive Design, pp. 3.2-3.3.
g) Coordinate use of spaces to take advantage of direct gain during day and thermal mass at night. (T) F							
h) Convert roof for use as roof pond for heating and cooling. (T) F							Passive Design, p. 6.9
i) Increase total amount of solar energy striking collector surface by taking advantage of reflectance from ground and adjacent building surfaces, and/or new material installed for this purpose. (T) F							Fuel Savers, pp. 24-25; Window Design, pp. 1.15-1.20.
j) Install storage devices. (T) F							Passive Design, pp. 7.8-7.10.

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
2.5 Reduce the heating effect of the sun in summer through landscaping. (An "X" indicates that if prevailing wind direction is the same in summer and winter, the measure may increase the heating bill.)							Plant a Tree, pp. 29-60, 108-276.
a) Erect permanent shading such as evergreen trees and shrubs, permanent fences. (X) F							
b) Erect seasonal shading such as deciduous trees, arbors, temporary fences. I							
3. VENTILATION							
3.1 Reduce ventilation rates.							
a) Reduce exhaust air quantities. (T) F							ECM-1, pp. 113-115, 167-168; ECM-2, p. 153; Survey Manual, pp. 29-30
b) Install new dampers to limit outdoor air intake. (T) F							ECM-2, p. 72.
c) Reduce or eliminate the need for using outdoor air for odor control by installing chemical or activated charcoal odor absorbing devices. (T) F							ECM-2, pp. 72-74.

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
d) If number of building occupants varies widely, install remotely adjustable outside air dampers to permit air volume to be adjusted in proportion to occupancy. (T) F							
e) Turn off all non-critical exhaust fans. (T) F							
3.2 Limit ventilation schedule.							
a) Establish a ventilation schedule so exhaust system operates only when it is needed. I							
b) Close outdoor air dampers during first and last hour of occupancy when air must be heated or cooled. I							
c) Use exhaust hoods in kitchens only while cooking is underway. If exhaust hood is oversized, adjust it to reduce volume. Use separate make up air supply for exhaust. H							ECM-2, pp. 74-75.
d) Cut off direct outdoor air supply to toilet rooms and permit air from other areas to migrate into restrooms through door grilles and be exhausted. (T) F							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
e) Shut down the ventilation system when the building is closed for an extended period. I							ECM-1, p. 112.
3.3 Install devices to permit energy conservation							
a) Install baffles to prevent wind from blowing directly into air intake. (T) F							
b) Use high efficiency, low cost filters and create a regular replacement schedule. (T) F							
c) Install economizer enthalpy controls to air handling units to minimize cooling energy required. (T) F							
d) When ventilation rate is over 10,000 CFM, and when building configuration permits, install heat recovery devices such as a rotary heat exchanger or enthalpy wheel. (T) F							ECM-2, pp. 232-234.

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
4. LIGHTING							
4.1 Maintain lighting system properly.							
a) Clean lamps regularly. I							ECM-2, p. 251; ECM-1, p. 243.
b) Check light output regularly with a calibrated light meter (efficiency deteriorates over the life of a lamp). (T) F							
c) When output of a group of lamps falls to 70% of original, relamp all fixtures in the group. H							
d) Clean reflecting surfaces and shielding of light fixtures regularly. I							ECM-2, pp. 251, 253.
e) Replace lens shielding that has yellowed or become hazy with clear non-yellowing acrylic. H							
f) Clean ceilings, walls, and floors to improve reflective qualities. I							ECM-1, p. 240.
g) Wash windows regularly to increase natural illumination. I							
4.2 Reduce illumination levels through modification of lamps (bulbs or tubes).							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
a) Conduct an illumination level survey. Compare existing levels to standards to identify areas where levels may be reduced. (T) F							ECM-1, pp. 233-238; TEM, pp. 32-33.
b) Replace present lamps with those of lower wattage. I							ECM-1, pp. 236-238; TEM, p. 33.
c) Remove unnecessary lamps. (When lamps are removed from a fluorescent fixture, all lamps controlled by a given ballast should be removed.) I							ECM-1, pp. 247-250; Survey Manual, pp. 60-61
d) Replace existing lamps with more efficient ones (more lumens per watt). (T) I							ECM-1, pp. 251-253; TEM, p. 33
4.3 Reduce illumination requirements by changing the placement and configuration of light fixtures.							
a) Relocate lights to provide more direct illumination on work areas and reduce overall illumination levels. (T) H							ECM-2, pp. 273-275; Survey Manual, pg. 67
b) Replace outdated or damaged fixtures with more efficient ones. H							ECM-2, pp. 268-269.
c) Replace incandescent lights with fluorescent fixtures. H							ECM-2, pp. 273-274.

WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
d) Lower fixtures so they will provide needed illumination levels on work areas at reduced wattage. H							ECM-2, pp. 272-273; Survey Manual, p. 68.
e) Install lenses which provide special light distribution patterns to increase lighting effectiveness. (T) H							ECM-2, pp. 252-259.
f) Use natural lighting to supplement or replace artificial illumination. I							ECM-1, p. 240; Window Design, pp. 5.1-5.6, 6.1-6.16.
4.4 Increase control of illumination levels.							
a) Use fluorescent fixtures with multiple level ballasts. H							ECM-2, p. 276.
b) Install dimmers on incandescent fixtures. H							ECM-2, pp. 273-274.
c) Provide selective switching instead of central panel boards for large areas of lights. (T) F							
d) Increase local control of lighting. H							ECM-2, pp. 259-260.
e) Monitor lighting use in remote areas at central stations. (T) F							
f) Install photocell switching to turn off banks of lights when natural daylight is sufficient. H							ECM-2, pp. 259-260.

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
g) Use time clock controls for those areas of a building which are used infrequently or for brief periods of time. H							ECM-2, pp. 259-260.
4.5 Reduce energy requirements for outdoor lighting.							
a) Reduce illumination levels by reducing the number of lights in operation and/or using lower wattage lamps. I							
b) Reduce or eliminate use of signs and decorations requiring illumination. I							
c) Cut down on the hours of operation of outdoor lights. I							
d) Use photocell or time clock controls for outdoor lights. H							
e) Switch to more efficient types of lighting. H							Street Lighting, pp. 34-36.
f) Keep fixtures clean. I							
5. DOMESTIC HOT AND COLD WATER							
5.1 Maintain systems properly. (See Water Conservation Section for additional measures.) I							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
a) Test hot water controls to determine if they are working properly. (T) F							
b) Regulate, repair, or replace defective controls. (T) F							
c) Inspect and repair insulation on tanks and pipes regularly. I							
5.2 Reduce heat losses in hot water system.							
a) Insulate hot water storage tanks. I							ECM-2, p. 116.
b) Insulate hot water pipes. I							ECM-2, pp. 115-116.
c) Relocate water heater as close to the point of use as possible to reduce quantity of water stored in pipes. (T) F							
5.3 Use hot water system more efficiently. (See Water Conservation Section for additional measures.)							
a) If hot water is distributed through forced circulation, turn off pump when building is unoccupied. (T) F							
b) Limit duty cycle on electric water heaters to avoid adding to periods of peak electrical demand. (T) F							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
c) If cooking facilities are used only on occasion, deactivate hot water system when not in use. I							
d) Reduce hot water temperature to 90°-100° F. Use higher temperatures locally for kitchens, and other areas where it is needed. (T) F							ECM-1, pp. 144-149; ECM-2, p. 117.
e) Use waste heat from other processes to preheat hot water. (T) F							ECM-2, p. 123.
5.4 Install more efficient water heating equipment.							
a) Install separate boiler for summer generation of hot water. (T) F							ECM-2, p. 117.
b) Replace central system with local heating units such as hot gas exchangers, hot drain exchangers, and hot condensate heat exchangers. (T) F							ECM-2, pp. 117-120; Food Service, pp. 61-62.
6. HVAC SYSTEM OPERATION							
6.1 Curtail heating operations.							
a) Preheat building so it achieves 65° F (or 5° F below normal daytime temperature) by the time people arrive, and finish warm-up during the first hour of occupancy. I							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
b) Turn heat off during last hour of occupancy. I							
c) Where sill height electric heaters are used, adjust thermostat so heat provided is just sufficient to prevent cold downdrafts from reaching the floor. I							
d) Use portable heaters to supplement system. I							
6.2 Curtail cooling operations.							
a) Begin precooling operations so that the building is 5° below outside air temperature or 80° F, whichever is higher, by the time people arrive, and finish cooldown during first hour of occupancy. I							
b) Flush the building with cool outdoor air at night. I							ECM-1, p. 159.
6.3 Curtail humidification/dehumidification operations.							
a) Allow natural humidity variations from 20%-60% relative humidity. I							ECM-1, pp. 108-111.
b) Reduce relative humidity levels in winter. I							

WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
c) Allow relative humidity to increase in summer. I							
d) Turn off humidifiers when building is closed for extended periods except where euqipment requirements take precedence. I							
e) Reduce or eliminate humidification for halls, equipment rooms, lobbies, and laundry areas. I							
7. HVAC SYSTEM MAINTENANCE							
7.1 Implement regular maintenance programs for all of the equipment listed below if it is contained in the building. These programs should include at a minimum the items listed on the Maintenance Checklist, pp. B-57-73. (T)							TEM, pp. 20-26; Survey Manual, pp. 51-55.
a) Refrigeration Equipment F							
b) Heating Equipment F							
c) Humidification and Dehumidification Equipment F							
d) Air Handling Equipment F							
e) Prime Movers - Motors, Engines, Turbines F							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
f) Fans and Pumps F							
g) Hot and Chilled Water Piping F							
h) Steam Piping F							
i) Pneumatic Air Compressor F							
7.2 Have your heating and cooling systems tested and balanced. Steps which can then be taken to increase the efficiency of your HVAC system equipment are outlined on the HVAC System Modification Checklist, pp. B-74-77. (T) F							TEM, pp. 26-28; Survey Manual, pp. 47-50; ECM-2, pp. 215-225.
8. HVAC DISTRIBUTION SYSTEM							
8.1 Improve the energy efficiency of hydronic distribution systems.							
a) Install insulation on all hot and chilled water pipes, fittings and valves passing through unconditioned space to minimize heat losses and heat gains. F							ECM-1, pp. 205-207; Survey Manual, pp. 15-17
b) Reduce parasitic loads by insulating pipes in heated spaces. F							ECM-2, pp. 77-85; ECM-1, pp. 205-208.
c) Replace fine mesh strainer baskets with ones having the largest practical openings to reduce pressure losses. (T) F							

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POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need W.A.	
d) Remove orifice plates not regularly used for flow measurement. (T) F							
e) Reduce resistance to flow in piping systems. The resistance to flow of any given piping system is the sum of the resistances of all its individual parts in the index circuit. Some of the parts cannot be easily modified, but others are candidates for reducing resistance. (T) F							ECM-2, pp. 194-200.
f) When the heating or cooling load is actually less than original design or is further reduced, the flow rate through the hot water or chilled water systems may be reduced in proportion, provided that the supply temperature set point is retained at its initial level. (T) F							ECM-2, pp. 75-77.
g) Balance hydronic systems to attain minimally satisfactory temperature and water flow. (T) F							ECM-1, pp. 204-205.
h) Trim impeller to actual size required on pump curve after terminal unit flows are reduced to the minimum. This will enable reductions of power requirements of actual load. (T) F							
i) Install flow measurement instrumentation where none now exists. (Factory-assembled pipe-mounted							

WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
instrumentation can easily be cut into the system.) (T) F							
j) Check sizing of valves, filters and pipe sections. All those which are undersized should be replaced. (T) F							
k) Check all pipe fittings. Replace those which are inefficient. (T) F							
l) Consider adding a parallel small-GMP pump to handle heating load for dual temperature changeover systems. (T) F							
m) Consider adding a variable speed drive. Although this will conserve energy, it will limit the pump's ability to handle flow to the farthest terminal units. (T) F							
B.2 Improve the energy efficiency of steam distribution systems.							
a) Install insulation on all mains, risers, and branches, economizers, water heaters, and condensate receiver tanks where none now exists. F							Survey Manual, pp. 21-23.
b) Add additional shut-off valves for more efficient zone control. (T) F							
c) Install recorder pressure gauges							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
and thermometers where none now exists to enable continual monitoring of the system. (T) F							
d) Modify equipment as necessary to recover heat now going to the sewer. Such reclaimed heat can be used to heat a portion of the building or to preheat water being supplied to the domestic hot water heater or be returned to the boilers. (T) F							
e) Install and/or replace steam traps. (T) F							Survey Manual, pp. 24-25.
8.3 Improve the energy efficiency of air distribution systems.							
a) Test, adjust and balance entire air distribution system in accordance with methodology suggested in the 1973 ASHRAE Handbook and Product Guide. (T) F							
b) Insulate all ductwork carrying conditioned air through unoccupied spaces with at least 1½" of fibrous insulation or its thermal equivalent. H							
c) Reduce system resistance to air flow to a minimum by replacing those duct sections and fittings which impose							ECM-2, pp.201-210.

WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
unnecessary resistance on the system; replacing dirty filters with adequately sized filter media which has high efficiency and low air flow resistance; removal of unnecessary dampers and other obstructions from ductwork and replacing high resistance inlets and outlets with modern grilles and diffusers providing low resistance. (T) F							
d) If air volume has been decreased to effect energy savings, determine resulting load on the fan motor. If it is less than 80% of name plate rating, consider replacing motor with a smaller one. (T) F							ECM-1, pp. 197-202; ECM-2, pp. 210-211.
e) Relocate air outlets or rearrange ductwork so that air entering the space does not first come into contact with hot surfaces. (T) F							
9. HVAC CONTROL, ADJUSTMENT AND MODIFICATION							
9.1 Inspect and test HVAC controls periodically. (T)							
a) Adjust controls whenever you test and balance the heating and cooling system. (T) F							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
b) Check and correct operation of entire HVAC control system, including control valves and dampers. (T) F							
c) Check control system for instrument calibration, and set point, actuator travel and action, and proper sequence of operation. (T) F							
d) Inspect and calibrate pressure controls on dual duct system to obtain minimum static pressure during low demand and less leakage. (T) F							
9.2 Adjust controls to permit energy conservation in heating and cooling systems.							
a) Relocate thermostats if they are in particularly warm or cold spots (on outside walls, near doors, in direct sunlight). (T) H							
b) Limit use of reheat to areas where humidity control is needed because of equipment requirements. (T) F							
c) Adjust controls to prevent simultaneous operation of heating and cooling systems. (T) F							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
d) Adjust automatic timers to turn off or turn down heating and cooling systems during evenings, weekends, holidays, or other unoccupied periods. I							
e) If a chilled water central plant is used for cooling, determine if the chiller can be shut down when outdoor temperature is below 50°. Add control valves and controllers which allow chilled water to flow from chillers to condenser water cooling tower to permit "free" cooling. (T) F							
9.3 Install devices which improve your ability to control the heating and cooling system.							
a) Install thermostats for all heating and cooling equipment. I							
b) Add controls to permit complete shutdown of air and water to unoccupied areas. I							
c) Install key-lock plastic covers over thermostats to prevent building users from changing settings. I							
d) Install clock thermostats. I							*Survey Manual*, pp. 31-32

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POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
e) Install program clocks and manual overcall timers in control circuits to permit scheduled operation of fans, refrigeration equipment, heating equipment, etc. (T) F							
f) Add time clocks on self-contained heating and cooling units for automatic shutoff. H							Survey Manual, p. 37.
g) Add a step controller to electric heating systems with resistance elements to permit staging. (T) F							
h) Use optimizing controls to operate equipment in most efficient modes. (T) F							
i) Investigate a central control system if the building is larger than 200,000 square feet and has utility bills (electricity plus fuel) of $3,000 or more per month. (T) F							Survey Manual, pp. 111-114.
10. ELECTRIC POWER (T)							
10.1 Conduct a load survey of the building's electrical system. (T) F							TEM, p. 37.
10.2 Reduce transformer losses, switchgear losses, and use efficient transformers. (T) F							ECM-1, p. 269; TEM, p. 38.

WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
10.3 Institute a demand management program. (T) F							ECM-2, pp. 296-297; TEM, pp. 38-39.
10.4 Conduct a power factor survey and correct the power factor. (T) F							ECM-2, pp. 297-300. TEM, pp. 39-40.
10.5 Reduce energy consumed by elevators and escalators. (T) F							ECM-2, p. 301; TEM, pp. 35-36.

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
11. Use of Space							
11.1 Consider modifying hours of work or changing schedules to reduce hours of building operation. I							
11.2 Coordinate scheduling of evening meetings or programs so that fewer buildings must be kept in operation. I							
11.3 Avoid placing desks, tables, and other work areas near cold surfaces such as uninsulated exterior walls in winter. I							
11.4 Coordinate use of space to take advantage of heat in winter and light from the sun during the day. I							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
11.5 Where practical, place all heat producing equipment, such as duplicating machines, in one area to permit better control of heating and cooling. I							
11.6 If possible, have people who work after regular hours work in proximity to one another to reduce lighting, heating, cooling, and ventilation requirements. I							
11.7 Schedule custodial work during the day. I							
11.8 Close off unused areas, and turn off heating and cooling to those areas. I							

WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
12. Heating, Cooling, and Ventilation							
12.1 Move furniture, wall hangings, or displays that obstruct air flow from supply and return air grilles and registers. I							
12.2 Close all windows when building is being heated or cooled. Post a sign next to each window to remind staff. I							
12.3 Keep all outside doors closed when not in use during the heating and cooling seasons. Post a sign on each door to remind staff and visitors. I							
12.4 During the heating season close all drapes and blinds at night to reduce heat losses, and open them during the day when the sun is shining. I							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
12.5 During the cooling season, close drapes and blinds on sunny days to avoid the heat of direct sunlight. I							
12.6 Heat building to 68°F maximum or less when occupied, to 60°F maximum when unoccupied in winter. I							
12.7 Cool building to 78°F when occupied, and do not use mechanical cooling when unoccupied. I							
12.8 Reduce use of heating and cooling systems in areas which are used infrequently or for short periods of time. I							
12.9 Shut off all heating in garages, loading docks, and platform areas. I							

WORKSHEET 1

POTENTIAL BUILDING MEASURES

Measures		Preliminary Assess.			Walkthrough Assess.			Technical Reference
		In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
12.10	Isolate storage room areas and maintain them at 60°F or lower in winter. I							
12.11	Reduce or eliminate heating in lobbies, corridors, and vestibules. I							
12.12	Turn off portable electric heaters and fans when not needed. I							
12.13	Turn on window and through-the-wall air conditioners or unit heaters only when needed, and turn them off when the area will be unoccupied for several hours. I							
12.14	Wear heavier clothing during the heating season and lighter clothing during the cooling season. I							

WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
12.15 Concentrate smoking areas together so that they can be served by one exhaust fan. I							
13 Lighting							
13.1 Turn off lights when they are not needed - leaving a light burning even for a short time never saves electricity. I							
13.2 Post a sign next to each switch indicating which lights it controls to avoid trial and error. I							
13.3 Relocate work stations to take best advantage of existing lighting systems. I							
13.4 If possible, group tasks which require the same levels of illumination together. I							

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WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	**Preliminary Assess.**			**Walkthrough Assess.**			**Technical Reference**
	In Place Planned	**N/A**	**Potential Activity**	**Applicable**	**N/A**	**Need T.A.**	
13.5 Locate work stations which require the highest levels of illumination near windows.							
13.6 Use natural lighting to supplement artificial lighting, and arrange desks or tables so that daylight crosses the task perpendicular to the line of vision.							
13.7 Turn off lighted signs and displays during unoccupied periods and perhaps during low traffic periods or altogether.							
14. Power Equipment							
14.1 Turn off electric typewriters, coffee pots, and calculators when not in use.							
14.2 Encourage staff and visitors to use stairways instead of elevators.							

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WORKSHEET 1

POTENTIAL BUILDING MEASURES							
Measures	Preliminary Assess.			Walkthrough Assess.			Technical Reference
	In Place Planned	N/A	Potential Activity	Applicable	N/A	Need T.A.	
15. Kitchens							
15.1 Turn off food warmers when no food is being warmed.							
15.2 Avoid using hot or warm water for dish scraping.							
15.3 Preheat ovens only for baked goods, and for minimum time necessary.							
15.4 Run dishwashers only when full.							
15.5 Cook with lids on pots and kettles.							
15.6 Use microwave ovens when they reduce power requirements.							
15.7 Turn off frying tables, steam tables, and coffee urns when not in use.							

SAMPLE

Worksheet II: Measures Evaluation

Measures	Potential Benefits	Action Required for Implementation	Barriers to Implementation	First Decision Point
2.3 Relocate the through-the-wall air conditioner in the administration building from south to north wall to take advantage of the shade	• Energy savings - unit will operate more efficiently • Cooler temperature and better humidity control • Improve appearance by removing unit from front to back [illegible]	• Approval to make alterations • Move unit and repair south wall • Move furniture inside if needed	• Unit will be outside chiefs office, noise may bother him at times	Go on
4.6 Isolate off-line chillers in cooling system for museum	• Energy savings during light cooling loads • Increased comfort due to increased efficiency of chilled water pumps	• Feasibility and cost study by air conditioning engineer	?	Study
Replace regular fluorescent lamps with energy savers	• Energy savings • Equal amount of light	• Purchase lamps and install as present ones burn out	None	Go on

SAMPLE

Worksheet II: Measures Evaluation (Part II)

	Cost	Savings ($ and BTUs)	Payback Period	Training Needs	Motivation Problems and Incentives
	$100 labor $150 materials	?	?	None	None
	Study cost - minimal				
	$150	$70/yr.	2 yrs.	None	None

MAINTENANCE
CHECKLISTS FOR BUILDINGS

REFRIGERATION EQUIPMENT
MAINTENANCE CHECKLIST

(from Total Energy Management, pp. 20-21)

Circuit and Controls

- Inspect moisture-liquid indicator on a regular basis. If the color of the refrigerant indicates "wet," it means there is moisture in the system because it can cause improper operation or costly damage. A competent mechanic should be called in to perform necessary adjustments and repairs immediately. Also, if there are bubbles in the refrigerant flow as seen through the moisture-liquid indicator, it may indicate that the system is low in refrigerant. Call in a mechanic to add refrigerant if necessary and to inspect equipment for possible refrigerant leakage.

- Use a leak detector to check for refrigerant and oil leaks around shaft seal, sight glasses, valve bonnets, flanges, flare connections, relief valve on the condenser assembly and at pipe joints to equipment, valves and instrumentation.

- Inspect equipment for any visual changes such as oil spots on connections or on the floor under equipment.

- Inspect the liquid line leaving the strainer. If it feels cooler than the liquid line entering the strainer, it is clogged. If it is very badly clogged, sweat or frost may be visible at the strainer outlet. Clean as required.

- Observe the noise made by the system. Any unusual sounds could indicate a problem. Determine cause and correct.

- Establish what normal operating pressures and temperatures for the system should be. Check all gauges frequently to ensure that design conditions are being met. Increased system pressure may be due to dirty condensers, which will decrease system efficiency. High discharge temperatures often are caused by defective or broken compressor valves.

- Inspect tension and alignment of all belts and adjust as necessary.

- Where applicable, lubricate motor bearings and all moving parts according to manufacturer's recommendations.

- Inspect insulation on suction and liquid lines. Repair as necessary.

- Provide controls to achieve the following:

  - raise chilled water temperature to "follow the load"

  - raise supply air temperature to follow the load

- permit relative humidity to rise in the conditioned air space
- decrease the superheat on DX coil
- fully load one compressor before starting the next refrigeration unit module
- install a new smaller refrigerator when existing modules are all oversized for light loads
- repipe chillers in series

Compressor

- Look for unusual compressor operation such as continuous running or frequent stopping and starting, either of which may indicate inefficient operation. Determine the cause and, if necessary, correct.
- Observe the noise made by the compressor. If it seems to be excessively noisy, it may be a sign of a loose drive coupling or excessive vibration. Tighten compressor and motor on the base. If noise persists, call a competent mechanic.
- Check all compressor joints for leakage. Seal as necessary.
- Inspect instrumentation frequently to ensure that operating oil pressure and temperature agree with manufacturer's specifications.

Air-Cooled Condenser

- Keep fan belt drive and motor properly aligned and lubricated.
- Inspect refrigeration piping connections to the condenser coil for tightness. Repair all leaks.
- Keep condenser coil face clean to permit proper air flow.
- Determine if hot air is being bypassed from the fan outlet to the coil inlet. If so, correct the problem.

Evaporative Condenser

- Inspect piping joints and seal all leaks.
- Remove all dirt from the coil surface by washing it down with high velocity water jets or a nylon brush.
- Inspect air inlet screen, spray nozzle or water distribution holes, and pump screen. Clean as necessary.
- Use water treatment techniques if local water supply leaves surface deposits on the coil.
- Follow guidelines for fan and pump maintenance.

Watercooled Condenser

- Clean condenser shell and tubes by swabbing with a suitable brush and flushing out with clean water. Chemical cleaning also is possible, although it is suggested that a water treatment company be consulted first.

Cooling Towers

- Perform chemical analysis to determine if solid concentrations are being maintained at an acceptable level.
- Check overflow pipe clearance for proper operating water level.
- Check fan by listening for any unusual noise or vibration. Inspect condition of V-belt. Align fan and motor as necessary.
- Follow guidelines for fan maintenance.
- Keep the tower clean to minimize both air and water pressure drop.
- Clean intake strainer.
- Determine if there is air bypass from tower outlet back to inlet. If so, bypass may be reduced through addition of baffles or higher discharge stacks.
- Inspect spray filled or distributed towers for proper nozzle performance. Clean nozzles as necessary.
- Inspect gravity distributed tower for even water depth in distribution basins.
- Monitor effectiveness of any water treatment program which may be underway.
- Replace air-cooled condensers by cooling towers.

Chillers

- Chillers must be kept clean. Inspect on a regular basis. Clean as necessary.
- Inspect for evidence of clogging. A qualified mechanic should be called in to service equipment in accordance with manufacturer's specifications.
- To increase chiller efficiency use low temperature condenser water.

- Light cooling loaders on a multiple chiller installation are often met by circulating chilled water through all chillers even though only one chiller is operating. This not only wastes pump energy by maintaining an unnecessarily high water flow rate through the system, but due to the bypass effect of off-line chillers, forces the remaining on-line chiller to produce chilled water at low temperatures to offset the mixing effect of the bypass. Under light loads, isolate the off-line chillers and reduce the chilled water flow rate.

- Where existing centrifugal chillers are driven by steam turbines and the exhaust steam is condensed before being returned as feed water to the boiler, an absorption chiller can be substituted for the condensor to produce additional chilled water from the waste heat.

- Isolate off-line chillers. Light cooling loads on a multiple chiller installation often are met by circulating chilled water through all chillers even though only one chiller is operating. This wastes pump energy by maintaining an unnecessarily high water flow rate through the system. It also forces the remaining on-line chiller to produce chilled water at low temperatures to offset the mixing effect of the bypass to meet the desired supply temperature and so causes the on-line chiller to operate at low evaporator temperatures (COP drops). Install isolating valves so off-line chillers can be isolated under light loads, thereby reducing chilled water flow rate. If multiple chilled water pumps are installed, shut off those that are unneeded. If multiple chilled water pumps are not installed, consider installing additional pumps or a multi-speed drive on the present pump.

Absorption Equipment

- Clean strainers and seal tank on a regular basis.

- Lubricate flow valves on a regular basis.

- Follow manufacturer's instructions for proper maintenance.

Self-Contained Units. (Windows and through-the-wall units; heat pump, etc.)

- Clean evaporator and condenser coils.

- Keep air intake louvers, filters and controls clean.

- Keep air flow from units unrestricted.

- Caulk openings between unit and windows or wall frames.

- Check voltage. Full power voltage is essential for proper operation.

- Follow applicable guidelines suggested for compressor, air-cooled condenser and fans.

HEATING EQUIPMENT
MAINTENANCE CHECKLIST
(from Total Energy Management, pp. 21-23)

Boilers (General)

- Inspect boilers for scale deposits, accummulation of sediment or boiler compounds on water side surfaces. Rear portion of the boiler must be checked because it is the area most susceptible to formation of scale. Scale reduces the efficiency of the boiler and possibly can lead to overheating of furnace, cracking of tube ends and other problems.

- Fireside of the furnace and tubes must be inspected for deposits of soot, flyash and slag. Fireside refractory surface also must be observed. Soot on tubes decreases heat transfer and lowers efficiency. (If your boiler does not now have one, consider installation of a thermometer in the vent outlet. It can save inspection time and often can prove to be more accurate than visual inspection alone.) If gas outlet temperature rises above normal, it can mean that tubes need cleaning. Evidence of heavy sooting in short periods could be a signal of too much fuel and not enough air. Adjustment of the air/fuel ratio is required to obtain clean burning fire.

- Inspect door gaskets. Replace them if they do not provide a tight seal.

- Keep a daily log of pressure, temperature and other data obtained from instrumentation. This is the best method available to determine the need for tube and nozzle cleaning, pressure or linkage adjustments, and related measures. Variations from normal can be spotted quickly, enabling immediate action to avoid serious trouble. On an oil-fired unit, indications of problems include an oil pressure drop, which may indicate a plugged strainer, faulty regulating valve, or an air leak in the suction line. An oil temperature drop can indicate temperature control malfunction or a fouled heating element. On a gas-fired unit, a drop in gas pressure can indicate a drop in the gas supply pressure or malfunctioning regulator.

- Note firing rate when log entries are made. Realize that even a sharp rise in stack temperature does not necessarily mean poor combustion or fouled waterside or fireside. During load change, stack temperatures can vary as much as 100°F in five minutes.

- Inspect stacks. They should be free of haze. If not, it probably indicates that a burner adjustment is necessary.

- Add an automatic draft damper control to reduce heat loss when gas or oil burner is turned off.

- Inspect linkages periodically for tightness. Adjust when slippage or jerky movements are observed.

- Observe the fire when the unit shuts down. If the fire does not cut off immediately, it could indicate a faulty solenoid valve. Repair or replace as necessary.
- Inspect nozzles or cup of oil-fired units on a regular basis. Clean as necessary.
- Check burner firing period. If it's improper, it could be a sign of faulty controls.
- Check boiler stack temperature. If it is too high (more than 150°F above steam or water temperature) clean tubes and adjust fuel burner.
- Check analysis of the flue gas on a periodic basis. Check oxygen and carbon monoxide as well as carbon dioxide. Oxygen should be present to no more than 1% or 2%. There should be no carbon monoxide. For a gas-fired unit, CO_2 should be present at 9% or 10%. For #2 oil, 11.5-12.8%; for #6 oil, 13 to 13.6%.
- Install flue gas analyzer to monitor combustion efficiency.
- The air-to-fuel ratio must be maintained properly. If there is insufficient air, the fire will smoke, cause tubes to become covered with soot and carbon, and thus lower heat transfer efficiency. If too much air is used, unused air is heated by combustion and exhausted up the stack, wasting heat energy. Most fuel service companies will test your unit free of charge or for a token fee only.
- Inspect all boiler insulation, refractory, brickwork, and boiler casing for hot spots and air leaks. Repair and seal as necessary.
- Replace all obsolete or little-used pressure vessels.
- Examine operating procedures when more than one boiler is involved. It is far better to operate one boiler at 90% capacity than two at 45% capacity each. The more boilers used, the greater the heat loss.
- Light heating loads on a multiple boiler installation are often met by one boiler on line with the remaining boilers idling on standby. Idling boilers consume energy to meet standby losses which can be further aggravated by a continuous induced flow of air through them into the stack and up the chimney. Unless a boiler is scheduled for imminent use to meet an expected increase in load, it should be secured and isolated from the heating system by closing valves and from the stack and chimney by closing dampers.
- Clean mineral or corrosion build-up on gas burners.

- Install boiler stack economizer. A boiler stack economizer is a simple heat exchanger placed inside the exhaust stack which uses boiler feed water as the transfer medium. Heat captured from the exhaust gases increases the temperature of the feed water distributed to the boiler. In past years this technique was limited to systems using low or non-sulphur content fuels to avoid build-up caused when the economizer cooled exhaust gases to the sulphur dew point. Newer systems overcome this problem by incorporating a solid-state control which keeps stack temperatures above the dew point. By controlling the volume of feed water passing through the transfer coils.

- Preheat oil to increase efficiency. Preheating oil can increase efficiency by as much as 3% depending on the particular constituents of the oil involved. Heat required to attain complete atomization can be obtained through use of reclamation procedures discussed below. Heating oil beyond 135°F for #4 oil, 185°F for #5, or 210°F for #6 will increase efficiency even more, except care must be taken not to overheat, which could cause vapor locking and flame-out. Recommendations of the oil supplier should be followed.

- Preheat combustion air to increase boiler efficiency. Preheating primary and secondary air increase boiler efficiency by reducing the cooling effect when the air enters the combustion chamber and by promoting more intimate mixing of fuel and air. It is estimated that each 100°F increase in combustion air temperature increases boiler efficiency by 2%. Combustion air can be preheated up to 600°F for prevalent fuels and up to 350°F for stoker-fired coal, oil and gas. The maximum temperature permissable is determined by the type of construction involved and the materials of the firing equipment. Several sources of heat are available to perform preheating. As an example, ambient air in most boiler rooms is heated incidently by boiler and pipe surfaces and collect below the ceiling. This air can be utilized directly as preheated combustion air by ducting it down to the firing level and directing it into the primary and secondary air intakes. Other methods available involve recovering waste heat from boiler stacks, condensate, blowdown hot wells, and other sources. Manufacturer's recommendations should be followed in all cases.

- Reduce blowdown losses. Blowing down a boiler has two purposes: (1) to maintain a low concentration of dissolved and suspended slides in the boiler water, and (2) to remove sludge in the boiler to avoid priming and carryover. There are two principal types of blowdown; intermittent manual blowdown and continuous blowdown. Manual blowdown (or sludge blowdown) is necessary whether or not continuous blowdown is installed, with frequency depending on the amount of solids in the boiler makeup water and the type of water treatment used. Continuous blowdown results in a steady energy drain because makeup water must be heated. In either case, blowdown energy losses can be minimized by installing automatic blowdown control and heat recovery systems. Automatic blowdown controls monitor the conductivity and pH of the boiler water periodically and blowdown the boiler only when required to maintain acceptable water quality. Further savings can be realized if the blowdown water is piped through a heat exchanger or a flash tank with a heat exchanger. In this way, for example, heat from the boiler blowdown flash tank can be used to feed reheating feed water heaters.

- Isolate off-line boilers. Light heating loads on a multiple boiler installation are often met by one boiler on line with the remaining boilers idling on stand-by. Idling boilers consume energy to meet stand-by losses. In many cases these losses are increased by a continuous induced flow of air through the idling boilers, and up the chimney. Unless a boiler is about to be used to meet an expected increase in load, it should be secured and isolated from the heating system (by closing valves) and from the stack and chimney (by closing dampers). A large boiler can be fitted with by-pass valves and regulating orifice to allow the minimum flow required to keep it warm and avoid thermal stress when it is brought on-line again. If a boiler waterside is isolated, it is important to prevent back flow of cold air through the stack which could cause the boiler to freeze.

- Replace boilers at or near end of useful life. A boiler at or near the end of its useful life should be replaced by a modern version which is matched to current and projected needs of the installation involved. In most cases new boilers on the market can obtain 80% efficiency. Even more efficiency can be gained by specifying multiple boilers and/or air-atomizing burners as appropriate. Replacement burners should be selected on the basis of long-term cost rather than first cost. Increased cost of fuel, labor and materials should be considered in developing long-term cost projections. Also consider installation of a dual-fuel system to avoid problems in the event of any shortages or curtailments.

- Replace existing boilers with modular boilers. Most boilers achieve maximum efficiency only when running at their rated output. In most cases, however, full boiler capacity is seldom required because heat load is 60% less than full load 90% of the time. As a result, large capacity boilers in single units operate intermittently for the major part of the heating season. Although hi-low firing capabilities may reduce cycling, the boilers can only reach their design efficiency for short periods resulting in low seasonal efficiencies. A modular boiler system comprising two or more small capacity boiler units will increase seasonal efficiency. Each module is fired at 100% of its capacity only when required. Fluctuations of load are met by firing more or less boilers. Each small capacity unit has low thermal inertia (providing rapid response and low heat-up and cool-down losses) and either will be running at maximum efficiency or will be turned off. In a typical installation where single unit large capacity boilers are replaced by modular boilers, boiler seasonal efficiency may be improved from 68% to 75%. This represents a 9% savings of present fuel consumption. Use of the modular approach is particularly worthwhile in cases where the present boiler plant is at or near the end of its useful life. Replacement modular boilers should be sized to meet the reduced heating load resulting from implementation of other measures.

Boilers (Fuel Oil)

- Check and repair oil leaks at pump glands, valves, or relief valves.

- Inspect oil line strainers. Replace if dirty.

- Inspect oil heaters to ensure that oil temperatures are being maintained according to manufacturer's or oil supplier's recommendations.

- Convert from steam atomizing burners to air-atomizing burners. Steam-atomizing burners consume at least 1.5% of total capacity to atomize the fuel oil. By contrast, air-atomizing burners rely on a simple electrically driven air compressor which costs far less to operate. Accordingly, when an existing steam-atomizing burner is at or near the end of its useful life, an air-atomizing replacement should be considered. In certain cases the savings to be obtained from an air-atomizing burner will warrant its installation prior to the scheduled replacement of the existing system.

Boilers (Coal-fired)

- Inspect coal-fired stokers, grates and controls for efficient operation. If ashes contain an excessive amount of unburned coal, it's probably a sign of inefficient operation.

Boilers (Electric)

- Inspect electrical contacts and working parts of relays and maintain in good working order.

- Check heater elements for cleanliness. Replace as necessary.

- Check controls for proper operation. Adjust as necessary.

Central Furnaces, Make-up Air Heaters and Unit Heaters

- All heat exchanger surfaces should be kept clean. Check air-to-fuel ratio and adjust as necessary.

- Inspect burner couplings and linkages. Tighten and adjust as necessary.

- Inspect casing for air leaks and seal as necessary.

- Inspect insulation and repair or replace as necessary.

- Follow guidelines suggested for fan and motor maintenance.

Radiators, Convectors, Baseboard and Finned-Tube Units

- Inspect for obstructions in front of the unit and remove whenever possible. Air movement in and out of convector unit must be unrestricted.

- Air will sometimes collect in the high points of hydronic units. It must be vented to enable hot water to circulate freely throughout the system. Otherwise, the units will short cycle (go on and off quickly), wasting fuel.

- Heat transfer surfaces of radiators, convectors, baseboard and finned-tube units must be kept clean for efficient operation.

Electric Heating

- Keep heat transfer surfaces of all electric heating units clean and unobstructed.
- Keep air movement in and out of the units unobstructed.
- Inspect heating elements, controls and, as applicable, fans on a periodic basis to ensure proper functioning.
- As appropriate, check reflectors on infrared heaters for proper beam direction and cleanliness.
- Determine if electric heating equipment is operating at rated voltage as necessary.
- Check controls for proper operation.

HUMIDIFICATION & DEHUMIDIFICATION EQUIPMENT
MAINTENANCE CHECKLIST

(from Total Energy Management, p. 23)

- Remove lint and dust periodically from air dampers, fan parts, spray chamber and diffuser, controls starter, and eliminator.
- Check equipment for carry-over. Carry-over may be maintained by adjusting eliminator seal gap, altering damper position, or changing air velocity.
- Follow guidelines suggested for fan and motor maintenance.

AIR HANDLING EQUIPMENT
MAINTENANCE CHECKLIST
(from Total Energy Management, p. 23)

- Inspect ductwork for air leakage. Seal all leaks by taping or caulking.
- Inspect ductwork insulation. Repair or replace as necessary.
- Utilize ductwork access openings to check for any obstructions such as loose hanging insulation (in lined ducts), loose turning vanes and accessories, and closed fire dampers. Adjust, repair or replace as necessary.
- Inspect damper blades and linkages. Clean, oil and adjust them on a regular basis.
- Inspect air valves in dual duct mixing boxes to insure full seating and minimum air leakage.
- Inspect mixing dampers for proper operation. Adjust as necessary.
- Clean or replace air filters on a regular basis.
- Inspect air heating, cooling and dehumidification coils for cleanliness. Coils can be kept clean by using a mixture of detergent and water in a high pressure (500 psig) portable cleaning unit.
- Inspect for leakage around coils or out of the casing. Seal all leaks.
- Inspect all room air outlets and inlets (diffusers, registers and grilles). They should be kept clean and free of all dirt and obstructions. Clean and remove obstructions as necessary.
- Inspect air washers and evaporative air cooling equipment for proper operation. Clean damper blades and linkages if so equipped. Inspect nozzles and clean as necessary.
- If electronic a[illegible]eaners are installed, check them regularly for excessive accumu[illegible]s on the ionizing and grounding plate section. Replace filter [illegible]ia if necessary. Follow manufacturer's written instructions whenever adjustment or maintenance is required.
- Inspect humidifier/dehumidifier air dampers, fan parts, spray chamber, diffuser, controls, strainer and eliminator. All must be kept free of dirt, lint and other foreign particles. Clean eliminator wheel by directing a high pressure stream of water between blades.
- Adjust all VAV (variable air volume) boxes so they operate precisely. This will prevent overheating or overcooling, both of which waste energy.
- Follow guidelines suggested for fan maintenance.

PRIME MOVERS - MOTORS, ENGINES & TURBINES
MAINTENANCE CHECKLIST
(from Total Energy Management, pp. 23-24)

Motors

- Check alignment of motor to equipment driven. Align and tighten as necessary.
- Keep motors clean.
- Eliminate excessive vibrations.
- Lubricate motor and drive bearings on a regular basis. This will help reduce friction and excessive torque which can result in overheating and power losses.
- Replace worn bearings.
- Tighten belts and pulleys to eliminate excessive losses.
- Check for overheating. It could be an indication of a functional problem or lack of adequate ventilation.
- Balance three-phase power sources to motors. An imbalance can create inefficient motor operation and use of more energy.
- Check for overvoltage or low voltage condition on motors. Correct as necessary.

Engines

- Follow manufacturer's recommended maintenance procedure.
- Check fuel consumption and compare with design fuel consumption.
- Record and check cooling water temperatures daily. If cooling water temperatures exceed manufacturer's recommendations, check temperature controls and correct as necessary.

Turbines

- Follow manufacturer's recommended maintenance procedures.
- Daily record steam pressure and check speed.
- Regularly check oil level, packing leakage, governor, and throttle valve operation.
- Record and check bearing temperatures.
- Record and check oil cooler temperatures.
- Weekly check vibrations.

FANS & PUMPS
MAINTENANCE CHECKLIST
(from _Total Energy Management_, p. 24)

Fans

- Check for excessive noise and vibration. Determine cause and correct as necessary.
- Keep fan blades clean.
- Inspect and lubricate bearings regularly.
- Inspect drive belts. Adjust or replace as necessary to ensure proper operation. Proper tensioning of belts is critical.
- Inspect inlet and discharge screens on fans. They should be kept free of dirt and debris at all times.
- Inspect fans for normal operation.

Pumps

- Check for packing wear which can cause excessive leakage. Repack to avoid excessive water wastage and shaft erosion.
- Inspect bearings and drive belts for wear and binding. Adjust, repair or replace as necessary.

PNEUMATIC AIR COMPRESSOR FOR CONTROLS
MAINTENANCE CHECKLIST
(from Total Energy Management, p. 25)

- Inspect all connections for air leaks using a soap solution. Seal as necessary.
- Note operation. If compressor seems to run excessively, it could be a sign of pressure loss at the controls or somewhere in the piping system. Determine cause and correct.
- Inspect air pressure in supply tank and pressure regulator adjustment in supply line for proper limits.
- Check belt tension and alignment.
- Inspect air compressor intake filter pads and clean or replace as necessary.
- Lubricate electric motor bearings according to manufacturer's recommendations.

HOT & CHILLED WATER PIPING
MAINTENANCE CHECKLIST
(from Total Energy Management, p. 24)

- Inspect all controls. Test them for proper operation. Adjust, repair or replace as necessary. Also check for leakage at joints.
- Check flow measurement instrumentation for accuracy. Adjust, repair or replace as necessary.
- Inspect insulation of hot and chilled water pipes. Repair or replace as necessary. Be certain to replace any insulation damaged by water. Determine source of water leakage and correct.
- Inspect strainers. Clean regularly.
- Inspect heating and cooling heat exchangers. Large temperature differences may be an indication of air binding, clogged strainers or excessive amounts of scale. Determine cause of condition and correct.
- Inspect vents and remove all clogs. Clogged vents retard efficient air elimination and reduce efficiency of the system.

STEAM PIPING
MAINTENANCE CHECKLIST
(from Total Energy Management, pp. 24-25)

- Inspect insulation of all mains, risers and branches, economizers and condensate receiver tanks. Repair or replace as necessary.
- Check automatic temperature-control system and related control valves and accessory equipment to ensure that they are regulating the system properly in the various zones - in terms of building heating needs, not system capacity.
- Inspect zone shut-off valves. All should be operable so steam going into unoccupied spaces can be shut off.
- Inspect steam traps. Their failure to operate correctly can have a significant impact on the overall efficiency and energy consumption of the system. Several different tests can be utilized to determine operations.
    - Listen to the trap to determine if it is opening and closing when it should be.
    - Feel the pipe on the downstream side of the trap. If it is excessively hot, the trap probably is passing steam. This can be caused by dirt in the trap, valve off stem, excessive steam pressure, or worn trap parts (especially valve and seats). If it is moderately hot - as hot as a hot water pipe, for example - it probably is passing condensate, which it should do. If it's cold, the trap is not working at all.
    - Check back pressure on downstream side.
    - Measure temperature of return lines with a surface pyrometer. Measure temperature drop across the trap. Lack of drop indicates steam blow-through. Excessive drop indicates that the trap is not passing condensate. Adjust, repair or replace all faulty traps.
- Inspect all pressure-reducing and regulating valves and related equipment. Adjust, repair or replace as necessary.
- Inspect condensate tank vents. Plumes of steam are an indication of one or more defective traps. Determine which traps are defective and adjust, repair, or replace as necessary.
- Check accuracy of recording pressure gauges and thermometers.
- Inspect pump for satisfactory operation, looking particularly for leakage at the packing glands.
- Correct sluggish or uneven circulation of steam. It usually is caused by inadequate drainage, improper venting, inadequate piping, or faulty traps and other accessory equipment.

- Correct any excessive noise which may occur in the system to provide more efficient heating and to prevent fittings from being ruptured by water hammer.
- Check vacuum return system for leaks. Air drawn into the system causes unnecessary pump operation, induces corrosion and causes the entire system to be less efficient.

HVAC SYSTEM MODIFICATION CHECKLIST

(from Total Energy Management, pp. 26-28)

Single Zone System

A zone is an area or group of areas in a building which experiences similar amounts of heat gain and heat loss. A single zone system is one which provides heating and cooling to one zone controlled by the zone thermostat. The unit may be installed within or remote from the space it serves, either with or without air distribution ductwork.

i. In some systems air volume may be reduced to minimum required, therefore, reducing fan power input requirements. Fan brake horsepower varies directly with the cube of air volume. Thus, for example, a 10% reduction in air volume will permit a reduction in fan power input by about 27% of original. This modification will limit the degree to which the zone serviced can be heated or cooled as compared to current capabilities.

ii. Raise supply air temperatures during the cooling season and reduce them during the heating season. This procedure reduces the amount of heating and cooling which a system must provide, but, as with air volume reduction, limits heating and cooling capabilities.

iii. Use the cooling coil for both heating and cooling by modifying the piping. This will enable removal of the heating coil, which provides energy savings in two ways. First, air flow resistance of the entire system is reduced so that air volume requirements can be met by lowered fan speeds. Second, system heat losses are reduced because surface area of cooling coils is much larger than that of heating coils, thus enabling lower water temperature requirements. Heating coil removal is not recommended if humidity control is critical in the zone serviced and alternative humidity control measures will not suffice.

Multizone System

A multizone system heats and cools several zones - each with different load requirements - from a single, central unit. A thermostat in each zone controls dampers at the unit which mixes the hot and cold air to meet the varying load requirements of the zone involved.

i. Reduce hot deck temperatures and increase cold deck temperatures. While this will lower energy consumption, it also will reduce the system's heating and cooling capabilities as compared to current capabilities.

ii. Consider installing demand reset controls which will regulate hot and cold deck temperatures according to demand. When properly installed, and with all hot deck or cold deck dampers partially closed, the control will reduce hot and raise cold deck temperature progressively until one or more zone dampers is fully open.

iii. Consider converting systems servicing interior zones to variable volume. Conversion is performed by blacking off the hot deck, removing or disconnecting mixing dampers, and adding low pressure variable volume terminals and pressure bypass.

Terminal Reheat System

The terminal reheat system essentially is a modification of a single-zone system which provides a high degree of temperature and humidity control. The central heating/cooling unit provides air at a given temperature to all zones served by the system. Secondary terminal heaters then reheat air to a temperature compatible with the load requirements of the specific space involved. Obviously, the high degree of control provided by this system requires an excessive amount of energy.

i. Reduce air volume of single zone units.

ii. If close temperature and humidity control must be maintained for equipment purposes, lower water temperature and reduce flow to reheat coils. This still will permit control, but will limit the system's heating capabilities somewhat.

iii. If close temperature and humidity control are not required, convert the system to variable volume by adding variable volume valves and eliminating terminal heaters.

Variable Air Volume System

A variable volume system provides heated or cooled air at a constant temperature to all zones served. VAV boxes located in each zone or in each space adjust the quantity of air reaching each zone or space depending on its load requirements.

i. Reduce the volume of air handled by the system to that point which is minimally satisfactory.

ii. Lower hot water temperature and raise chilled water temperature in accordance with space requirements.

iii. Lower air supply temperature to that point which will result in the VAV box serving the space with the most extreme load being fully open.

iv. Consider installing static pressure controls for more effective regulation of pressure bypass (inlet) dampers.

v. Consider installing fan inlet damper control systems if none now exist.

Constant Volume System

Most constant volume systems either are part of another system - typically dual duct systems - or serve to provide precise air supply at a constant volume.

i. Determine the minimum amount of airflow which is satisfactory and reset the constant volume device accordingly.

ii. Investigate the possibility of converting the system to variable (step controlled) constant volume operation by adding the necessary controls.

Induction Systems

Induction systems comprise an air handling unit which supplies heated or cooled primary air at high pressure to induction units located on the outside walls of each space served. The high pressure primary air is discharged within the unit through nozzles inducing room air through a cooling or heating coil in the unit. The resultant mixture of primary air and induced air is discharged to the room at a temperature dependent upon the cooling and heating load of the space.

i. Set primary air volume to original design values when adjusting and balancing work is performed.

ii. Inspect nozzles. If metal nozzles, common on most older models, are installed, determine if the orifices have become enlarged from years of cleaning. If so, chances are that the volume/pressure relationship of the system has been altered. As a result, the present volume of primary air and the appropriate nozzle pressure required must be determined. Once done, rebalance the primary air system to the new nozzle pressures and adjust individual induction units to maintain air flow temperature. Also, inspect nozzles for cleanliness. Clogged nozzles provide higher resistance to air flow, thus wasting energy.

iii. Set induction heating and cooling schedules to minimally acceptable levels.

iv. Reduce secondary water temperatures during the heating season.

v. Reduce secondary water flow during maximum heating and cooling periods by pump throttling or, for dual-pump systems, by operating one pump only.

vi. Consider manual setting of primary air temperature for heating, instead of automatic reset by outdoor or solar controllers.

Dual-duct System

The central unit of a dual-duct system provides both heated and cooled air, each at a constant temperature. Each space is served by two ducts, one carrying hot air, the other carrying cold air. The ducts feed into a mixing box in each space which, by means of dampers, mixes the hot and cold air to achieve that air temperature required to meet load conditions in the space or zone involved.

i. Lower hot deck temperature and raise cold deck temperature.

ii. Reduce air flow to all boxes to minimally acceptable level.

iii. When no cooling loads are present, close off cold ducts and shut down the cooling system. Reset hot deck according to heating loads and operate as a single duct system. When no heating loads are present, follow the same procedure for heating ducts and hot deck. It should be noted that operating a dual-duct system as a single duct system reduces air flow, resulting in increased energy savings through lowered fan speed requirements.

Fan Coil System

A fan coil system usually comprises several fan coil units, each of which consists of a fan and a heating and/or cooling coil. The individual units can be located either in or remote from the space or zone being served.

i. Reduce air flow to minimally satisfactory levels.

ii. Balance water flows to minimally satisfactory levels.

iii. When heating and cooling loads are minimal, shut off fans so enabling the coil to act as a convector.

iv. Consider installing interlocks between the heating and cooling systems of each unit to prevent simultaneous heating and cooling.

v. Consider face zoning two-pipe systems from four-pipe central system to avoid changeover losses.

Self-contained Systems

i. If multiple units are involved, consider installation of centralized automatic shut-off and manual override controls.

ii. If units are relatively old, consider replacing them with more efficient air-to-air heat pumps or similar units having a higher equivalent efficiency rating.

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ABSTRACTS

Core Sources

Energy Conservation in Building Design, Wash., DC: The American Institute of Architects Research Corporation, 1978.

This report discusses some of the ways architects can save energy in their building designs, although others in related professions concerned with energy conservation will find much useful information.

One section is on physical design alternatives and outlines areas of the building process where energy savings may be achieved and tradeoffs that need to be considered. The areas of the building process are: site analysis; building orientation; configuration; envelope; space planning; transportation; ventilation; heating; cooling; electric power; lighting; domestic hot water; and waste management. Another section looks at alternative sources of power. The appendix includes energy flow diagrams and case studies. Illustrations complement the very readable text.

Energy Management in Municipal Street Lighting. Boston, MA: Massachusetts Department of Community Affairs, 1977.

While most of this information is specific to Massachusetts' municipalities, some information can apply to a wider audience. A general discussion on evaluating one's lighting system is followed up with a description of four outdoor lighting categories -- commercial, arterial, high safety, and residential. The lighting needs and IES standards are indicated for each category.

Also of interest in this publication are chapters on "The Basics of Good Lighting" and "Lighting Technology." These chapters enable the reader to analyze one's lighting system in relation to lighting needs and current technology.

Energy Survey Manual, Wash., DC: Dept. of the Interior, 1977.

This manual was written to provide DOI field personnel with information on how to conduct energy surveys. An overall methodology to conduct broad energy surveys and identify cost effective retrofit opportunities is presented, along with an inspection procedure checklist. HVAC systems are described including options for retrofit, and energy audit procedures. Retrofit options are also described for lighting and domestic hot water systems, followed by a brief discussion of the effects of the building envelope on all systems. Systems Controls monitoring devices are presented as energy management systems.

Appendices include building forms, survey tables presenting climate data, lighting levels, ventilation air requirements, as well as checklists, a glossary and bibliography.

Guide to Energy Conservation for Food Service, Wash., DC: FEA, 1977, 74 pp.

Excellent "How to" procedures for saving energy are offered for food service operators.

Food Preparation and Storage focuses on efficient operation and maintenance of cooking equipment. The major pieces of energy-consuming equipment considered are rangetops, griddles, broilers, ovens, fryers, steamers, refrigerators, and freezers.

Lighting contains directions on how to conduct a lighting survey that will accurately determine where energy savings can be made and how to maintain the most efficient lighting systems.

HVAC first describes the operation of heating, ventilating, and air conditioning (HVAC) systems. It then provides tips on operation and maintenance that will reduce energy use.

Sanitation explains how to save energy in dishwashing and water heating processes. Operational procedures and simple maintenance tasks are included.

The appendix provides worksheets which can be used to determine energy savings.

The format of each section emphasizes operation, maintenance and planning. The guide is nontechnical and presents only guidelines to follow in managing energy use. An energy usage chart is inserted on which you can track monthly BTU and dollar costs.

Guidelines for Saving Energy in Existing Buildings--Building Owners and Operators Manual (ECM 1), Wash., D.C.: Federal Energy Adm., 1975, 300 pp.

This manual is designed to be used by building owners, managers, operators and occupants. It presents a set of guidelines to reduce energy waste in existing buildings through changes in the operation of mechanical and electrical equipment. While much of the emphasis is on those buildings that are in use relatively few hours per week, such as offices, schools and religious buildings, the principles of energy conservation discussed are applicable for other types of buildings as well.

Comments: At first glance this manual would appear to be too technical for the average building owner, operator or occupant. Experience in reading and using tables, graphs and charts is definitely required, but a study of any portion of the Manual will show that the explanations and examples are fully explained and simply presented. An important feature of the Manual is that it is usable anywhere in the United States. Furthermore, the data tables permit consideration of most variables that are likely to be encountered.

In the Bank...Or Up The Chimney?, Wash., DC: Dept. of Housing and Urban Development, 1977, 173 pp.

A manual of safe and cost-saving energy conservation techniques for the homeowner is organized into four parts:

1. A Quick Look at Your Home gives several easy-to-follow tips that will reduce fuel consumption and waste without major investment.
2. A Closer Look at Your Home gives a more individualized approach to home energy savings. The best and least expensive methods of retrofitting a house are suggested by first determining exactly what each house needs.
3. How to Do It gives step-by-step directions for installing energy saving materials. In addition, it gives general information on how to find a good contractor to do the work.
4. More...on how to save heating and cooling energy and...coming soon for your home gives simpler energy-saving tips and briefly describes sun and wind energy and waste heat recovery.

The simple language, easy-to-follow graphics and step-by-step installation instructions make it a useful guide for home owners.

Landscape Planning for Energy Conservation, Gary Robinette (ed.), Environmental Design Press, Reston, Virginia, C. 1977.

Especially helpful to the site planner, this book also contains information that can help the maintenance and operations staff improve or change the landscaping to conserve energy.

The first sixty pages discuss climate, its importance for human comfort, and the natural means by which it is modified. Natural elements which alter the effects of gross climatic conditions are:

- Land forms - Mountains, hills, etc., can change temperature, precipitation, and wind patterns.

- Vegetation - Trees, shrubs, and grass can influence temperature, wind flow, and humidity.
- The insulating effect of water bodies is also briefly discussed.

The second major topic is "Site Analysis," occupying another third of the text. The final section, "Case Studies," contains examples of successful landscape planning in each of the five different climatic regions of the U.S. Although organizational structure and layout create some confusion, many good diagrams are contained in this volume, clearly illustrating such topics as windbreaks and solar radiation control.

Insulating the Old House, Sally E. Nielsen. Portland, ME: Greater Portland Landmarks, Inc., C. 1977.

Written for the homeowner, this handbook resulted from the findings of a workshop, "Insulating the Old House," held in Maine in October 1977. Heat loss is addressed as it relates specifically to early New England dwellings. The focus is on those characteristics peculiar to these houses, such as their inherent energy efficiency (due to siting, massing, etc.), their adaptability to modern standards of comfort and efficiency, and the importance of preserving the integrity of the old building as an historical structure.

The bulk of this handbook presents technical information and analysis of typical problem areas in the old house. Housing types are diagrammed, conditions for analysis are outlined, and percentage of heat loss through major building components is estimated, giving the reader a rough idea of where improvement would be most cost-effective. A general overview of alternative solutions is then presented in the final section of the book, along with a brief discussion of installing insulation and eliminating moisture problems.

Passive Design Ideas for the Energy Conscious Architect, National Solar Heating and Cooling Information Center. Rockville, MD.

This publication for architects and planners stresses energy CONSCIOUS design, or incorporating passive design ideas and using solar energy through passive systems in its planning, design, construction, and use. Building location siting, orientation, configuration, layout, construction, mechanical and electrical systems, casework and interior furnishings are evaluated in terms of their contribution to energy consumption and conservation. Eight passive design concepts are given--introduction, building configuration, atriums, and greenhouses, using earth to save energy, dynamic structures, building envelope, windows and passive solar collectors, and interior subsystems.

BUILDINGS

The Fuel Savers: A Kit of Solar Ideas for Existing Homes, Dan Scully, Don Prowler, & Bruce Anderson, Harrisville, NH: Total Environmental Action, Inc., C. 1978, 60 pp.

This redesign of the original 1975 edition is skillfully organized and illustrated in a lively style. Some background information on energy conservation concepts -- winterization, infiltration, and conduction -- and solar energy is given, but the bulk of the information falls into the section "A Kit of Ideas." Each idea, such as thermal mass or glassed-in porch, is defined, possible variations of the idea are suggested, where the idea may be applied is given and advantages and disadvantages are listed. To give the homeowner or "do-it-yourselfer" an idea of the relative merits of each idea from the point of view of energy saved per dollar spent, "materials cost," "fuel reduction," and "cost-effectiveness" are considered. No labor costs are included. The fuel reducton is in terms of oil, and an oil barrel diagram for each idea illustrates its relative cost-effectiveness.

The Energy-Saving Guidebook, George S. Springer & Gene E. Smith, Westport, Ct.: Technomic Publishing Co., Inc., C. 1974, 103 pp.

This guide is intended for home owners and mobile home owners who need to know how they can save energy at home, on the road, at work, and at play. Useful suggestions applicable in different regions (north, south, urban, rural) are included.

Of particular interest, is Chapter 5, "Tips for the Mobile Home Owner" in which ideas are outlined with regard to insulation and sun protection to avoid excess heat absorption in hot weather.

Time-Life Home Improvement Series: Weatherproofing, Alexandria, Va., Time-Life Books, C. 1976, 128 pp.

In a well-illustrated book, ways for the home owner to weatherproof a house are presented in step-by-step fashion. The first chapter is devoted to sealing up gaps in a house which would allow heat to escape or enter--weatherstripping and types of sealants are described. The next chapter focuses on moisture and such options as gutters; drains; dry wells; waterproofing; sump pumps; asphalt, slate and wood shingle roofs; resealing; vents for air flow (gable, roof, and peak vents); and exhaust fans/ducts. In the third chapter, insulation and vapor barriers are described. The types, packing, and amount of insulation are shown; how to put it in as well as how to select areas in need of insulation are enhanced by illustrations that make it easy for the average home owner to follow. For those people working with finished walls, ways of getting insulation into the walls are shown.

Total Energy Management, Wash., DC: National Electrical Contractors Association.

Total Energy Management (TEM) is an energy conservation approach based on the premise that to effect energy savings in buildings one must make the building's systems as efficient as possible.

Initial efforts involve review of the building's past energy consumption characteristics and development of an Energy Utilization Index which indicates how much energy (in BTUs) the building consumes per gross square foot. Based on this factor and review of general conservation procedures possible, an initial energy conservation goal is established.

Once the initial goal is set, a comprehensive building survey is undertaken to determine where opportunities for energy conservation exist. In many cases significant energy waste can be eliminated through repair of faulty equipment, improved maintenance and operating practices. Numerous other options are available, some requiring little change from current procedures, others involving modifications much broader in scope.

Following review of the methods available to turn opportunities into actual savings, establishing priorities based on time and budget available, specific user needs, and related business, and productivity considerations unique to the building are undertaken.

Plant a Tree, Michael A. Weiner, New York: Collier Books, C. 1975, 277 pp.

Information on choosing the best tree(s) for a given climatic zone is provided in this well-organized and easy to read book. One chapter, "Selecting a Tree," opens with one basic general rule: Plant trees that are found growing naturally in a region because they are usually best adapted to local conditions. Lists of trees are provided that will prosper in each of nine regions of the United States. Most successful varieties and best spacing of trees for shelterbelts, woodlots, and urban strips are given. Another chapter tells how to buy a tree; what qualities to look for; how to prepare the soil; when and how to plant, prune, water, and mulch; and how to choose, dig up and transport wild trees. Ways of maintaining trees are provided, including use of predators, tree parasites, or "soft" pesticides. The latter half of the book gives a thorough listing of more than 160 North American tree species and their characteristics. We are told where each can be grown successfully, whether it is deciduous or evergreen, the type of shade it provides, its life expectancy and growth rate, how to propagate it, and what soil quality it requires.

Window Design Strategies to Conserve Energy, Wash., D.C., U.S. Dept. of Commerce, National Bureau of Standards, 1977, 209 pp.

Design strategies to improve performance and achieve energy-efficient windows are described for professional designers, lessees and owners of commercial space, home owners, and researchers. Each window design strategy is described in a consistent format under the following headings: strategy, phenomena, advantages, disadvantages, aesthetics, costs, examples, and references. The window design strategies include the following:

1. Site discusses the key considerations in siting a building to provide favorable window orientation (windbreaks, shading ground surfaces, orientation to the sun, and orientation to the wind).

2. Exterior Appendages covers improved window performance with exterior appendages: sun screens, exterior roll blinds, architectural projections, exterior shutters, and awnings.

3. Frame discusses frame composition and construction including frame ventilators, weatherstripping, thermal breaks, types of operation, window tilt, and size/aspect ratio.

4. Glazing discusses types of glass used in windows including multiple glazed glass, heat-absorbing glass, reflective glass, applied films, reduced glazing, glass block, and the thru-glass ventilator.

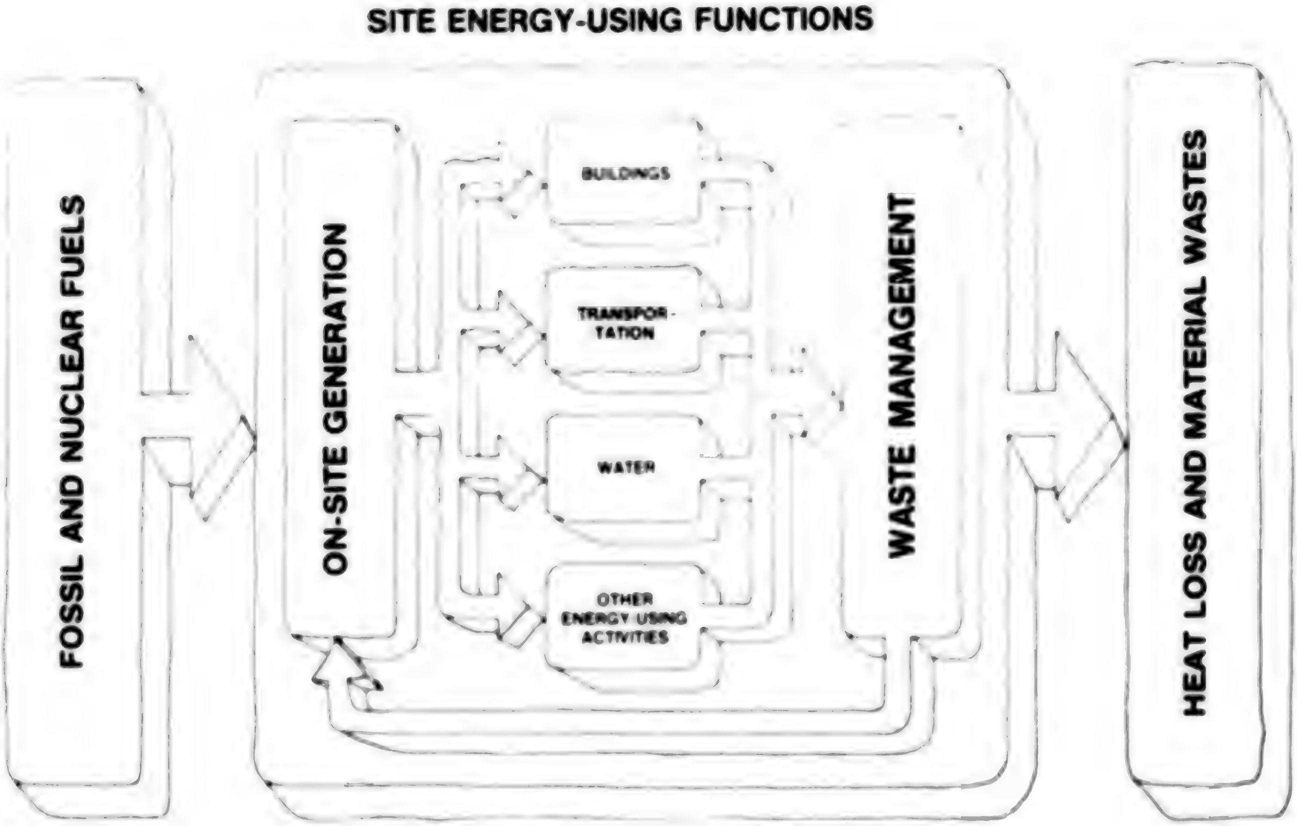
5. Interior Accessories addresses the use of venetian blinds, draperies, film shades, opaque roll shades, and insulating shutters for improved window performance.

6. Building Interior discusses the design of the illumination and mechanical systems, the design and color selection of room surfaces and the placement of massive building components to determine how the energy gained by the windows can serve to reduce illumination, air conditioning, and heating energy costs.

Each chapter is full of illustrations and photographs to complement the text. A glossary of terms used in window design and energy conservation introduces the document.

Transportation

VOLUME I
BOOK 3



This section on Transportation is part of a two volume Planning Guide designed to help you formulate an overall site-specific Energy Conservation Management Plan. It provides you with background information concerning how different types of vehicles use energy, as well as instructions for choosing and developing measures for making transportation at the site more energy efficient.

TRANSPORTATION

TRANSPORTATION AS AN ELEMENT OF THE SITE SYSTEM

The transportation system is one of the largest energy users at most sites, second only to buildings. It is a vital element in the site system because it provides a link to all other elements. The roads, trails, and vehicles connect buildings to one another, visitors to scenic areas, disposal sites, towns, and so forth.

Energy consumption in transportation is commonly seen as solely gasoline-related. The energy required to construct roads and manufacture vehicles and vehicle parts is ignored. In looking at the energy costs of operating a car, the following should be considered: gasoline refining and retail sales; highway construction; automobile manufacturing; parking facilities; repairs, maintenance, and parts; insurance; tire manufacturing and retail sales; automobile retail sales; and oil consumption, refining, and retail sales.(1) Gasoline consumption accounts for about 60% of the energy used by automobiles, while the remainder of the services necessary to produce and maintain the automobile account for 40% of the total energy use.

Due to the sheer volume of energy used in transportation, there is a considerable amount of waste. The transportation system has proved to be the most inefficient of energy users, wasting approximately 75% of the energy it consumes. Therefore, transportation offers a tremendous opportunity for substantial energy savings.

As with other energy-using systems, the transportation systems and components use energy inputs to provide a desired function. In Figure 1, an automobile is the energy-using system. Gasoline is the principal energy input, although there are others, such as direct human labor, motor oil, and other materials required to maintain it in proper running order. The automobile provides the desired function of transporting people and materials around the site, but is also a source of considerable waste. Using figures for typical automobiles in the U.S. in 1976, about 25% of the fuel energy is used directly to provide the desired function. The remaining 75% is lost

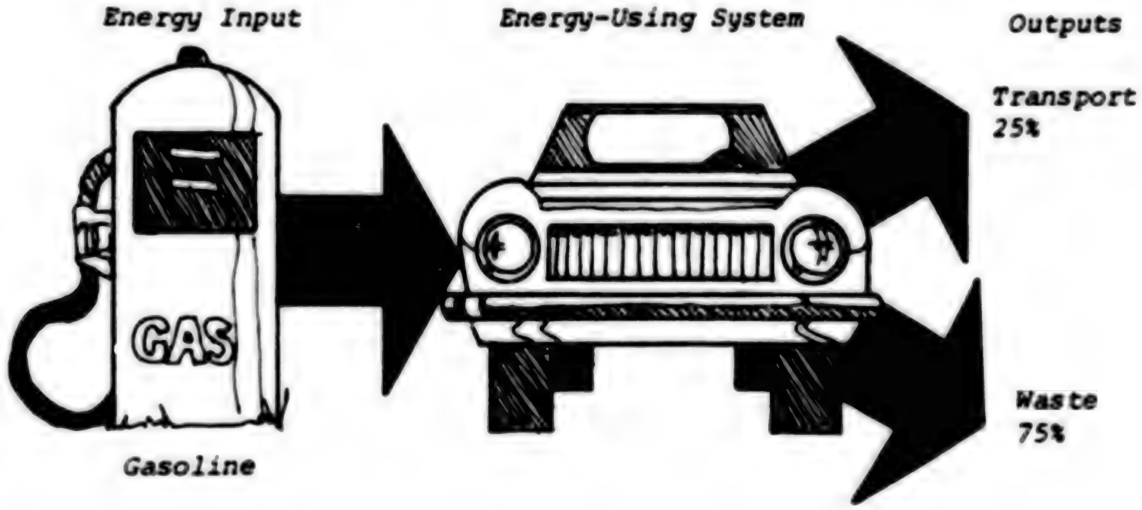


Figure 1 *Energy Flow*

to the surrounding atmosphere as waste.

Our primary goal in conserving transportation energy is to reduce inputs of nonrenewable energy sources. This can be accomplished by: 1) reducing use of transportation systems; 2) improving the efficiency with which energy is used, thereby reducing waste (or outputs); and 3) replacing nonrenewable with renewable energy sources.

On the following pages, energy inputs, uses, and outputs are discussed. Major energy conservation opportunities will be explained, and their relationship to the refuge or hatchery as a whole will be considered.

Fuels (Inputs)

The major fuel used by the transportation system at most refuges and hatcheries is gasoline. While Figure 2 does not represent site-level energy consumption, it does indicate the fuels used directly and indirectly in transportation in general. The figure gives you an idea of the magnitude and relative percentages of energy use in transportation.

Possibilities for using natural energy sources such as wind or sun in transportation systems are being explored. However, there are presently no practical and widely available technologies for doing this.

Desired Functions (Outputs)

Primary tasks of transportation systems include:

1. Transporting employees and visitors
2. Transporting freight/materials
3. Patrolling

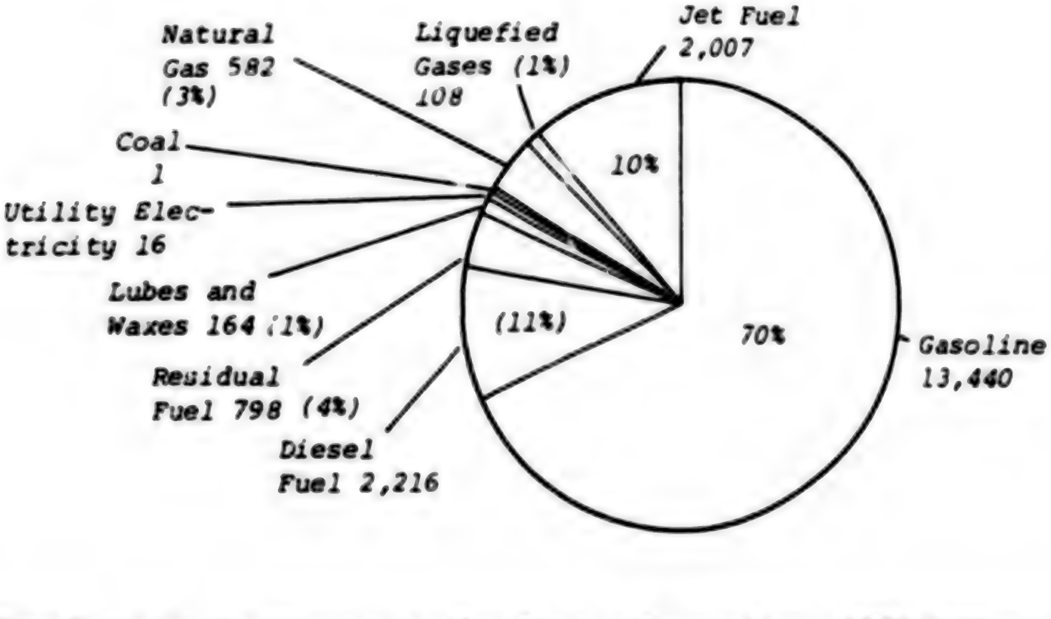


Figure 2 *U.S. Net Transportation Energy Consumption, 1976 Estimate 10^{12} BTU (Total Net Energy Consumption: x 10^{12} BTU) (Source: Reference (3))*

4. Rescue/special service for fires, accidents, and other emergencies

5. Providing roads and pathways to make areas accessible to vehicles.

Energy-Using Components: Vehicles

Vehicles used for passenger travel and freight transport range from bicycles to 10 ton trucks. Some of the major possibilities for energy savings in various transportation modes are discussed briefly below.

Automobiles

The passenger car is the largest consumer of transportation energy in this country. This holds true for most refuges and hatcheries if visitor and employee automobiles are counted with the vehicle fleet. Due primarily to public demand, automobile manufacturers have come to realize the importance of fuel economy. Many automobiles are now available which combine body design modifications, more efficient engines, lighter weight, and other improvements to achieve better fuel performance. Some vehicles, however, still have energy-consuming accessories such as air conditioning, power steering, and automatic transmissions which detract from fuel economy.

Buses

For the refuge or hatchery, buses may be more efficient than passenger cars for certain tasks, such as transporting visitors. Bus service for bringing visitors to a site may lack speed, convenience, mobility and reliability. However, these problems can be overcome when buses are used within the site. If traffic congestion is a major problem, then closing roads to passenger cars and opening them to buses should improve mobility and speed of transit.

Airplanes/Helicopters

While airplane travel tends to be very costly in terms of fuel consumption, planes serve two important functions: 1) they allow travel to remote areas where roads are non-existent and conditions are hazardous, and 2) they serve as rescue vehicles. They are also used to spray for insects or pests, chiefly for environmental or agricultural reasons. The fuel efficiency of air travel increases with the distance of the trip. Increasing passenger loads to capacity also improves efficiency. However, for the planes in use at refuges and hatcheries, these efficiency measures are not practical. Regular maintenance should be mandatory.

Recreational Vehicles

The energy inefficiencies of recreational vehicles may be offset somewhat if they are used for long stays at one site and if other modes, such as bicycles, are used for short trips at the site.

Boats

Unless they are hauled back and forth to the beach or lake each time they are used, canoes, rafts, and sailboats use very little energy for maintenance and operation. Motorboats use more energy, but lighter boats with small horsepower engines which are run at slower speeds show better fuel economy than heavier boats. Extra weight, such as an extra passenger, affects the fuel economy of a light boat more than a heavy boat. Some of the government boats operated at the site are used to protect visitor safety, requiring operating the boat in rough water and heavy winds. These conditions do tend to reduce gas mileage.

Certain measures may be taken to operate boats more energy efficiently. Regular maintenance is needed: servicing the engine regularly; checking the spark plugs; keeping the hull clean of barnacles and seaweeds; and making sure all fuel is drained out of the fuel tank, fuel lines, and carburetor if the boat is taken out of the water for winter months.(4)

Mopeds/Motorcycles

When Consumer Reports tested mopeds on a 30-mile fuel economy test course, they found that they were getting about 100 miles per gallon.(5) For many of the tasks at a refuge or hatchery, the moped may be the most efficient mode of transportation available. The moped would not be effective in enforcing speed limits, since any car could quickly outdistance it. But in performing other patrolling tasks where speed is not a requirement, the moped would be more than adequate. However, Consumer Reports also found that mopeds have the following disadvantage: "in some ways a moped engine is far 'dirtier' than a modern V8 engine with 100 times the displacement."(6)

If motorcycles are to be used at the site for patrolling or other tasks, bikes with a small horsepower engine (such as 10 hp) will be more economical in terms of gas mileage and energy savings than the larger bikes, which may use as much gas as a passenger car while carrying fewer people.(7)

Bicycles

Bicycles are a popular mode of transportation for visitors, and if made available to staff, could prove popular. An EPA report points out that riding bicycles is more energy efficient than walking: a bicyclist who rides at 10 mph uses only 97 Btu per passenger mile, while a pedestrian who walks at 2.5 mph uses 500 Btu per passenger mile.(8) Walking should not be overlooked, however, since it is more energy efficient than almost all other modes of transportation.

Safety is an important consideration for both bike riding and walking. Special bike and pedestrian paths or trails that are well maintained -- that is, free of broken bottles, litter, or potholes -- can improve the safety record of a refuge or hatchery, while stimulating people to ride bikes and walk. Safe and convenient bike racks and parking areas should be available to visitors and employees to encourage use.

Snowmobiles

A number of factors affect the fuel economy of snowmobiles. The low horsepower, four-stroke engines used in this type of vehicle give the best mileage when driven slowly. As with other vehicle types, towing with snowmobiles reduces fuel economy. Weather conditions and type of snow also affect mileage.

Railroads

Railroads can be very efficient for freight and passenger transport, having improved tremendously over the years as more efficient engines have been used and the fuel has changed from coal and residual fuel oil (steam engines) to diesel fuel. Their main drawback is inconvenience. They are not usually close enough to sites to make railroad transport a regular practice. For visitors arriving by railroad there is the added problem of needing additional transport to and within the site.

Trucks

Trucks are large users of gasoline and diesel fuel. They move all types of materials. In contrast to all other modes of freight transportation, trucks offer flexibility on pickup and delivery points: they provide door-to-door service. This is an important consideration for refuges and hatcheries, since railroad lines and waterways are often at inconvenient distances.

Pickup trucks are especially popular. Fuel savings may be realized by matching the pickup to the tasks that must be performed. If a pickup truck is required, one with 2-wheel drive will perform more energy efficiently than one with 4-wheel drive.

For automobiles, tractors, and trucks, diesel engines are proven energy savers, although initial costs (particularly for automobiles) may be high. The cost of diesel fuel as compared to gasoline should be considered before purchasing a diesel engine.

Tractors

Tractors are used for mowing, transporting materials, and for agricultural purposes. A diesel tractor will use 30% less fuel than a tractor using gasoline, while a tractor using propane gas for fuel will use 20% more fuel than a gasoline tractor.(9) Tractors with all gear power transmission are 25% more efficient in their use of fuel than those with hydraulic drive, even at reduced engine speed and partial load.(10)

Energy-Using Components: Roads and Paths

Stressing the importance of energy conservation in road design and maintenance can ultimately result in improved fuel economy and reduced maintenance requirements. The following factors related to road design affect the energy use of vehicles traveling these roads: type of road surface, road and shoulder widths, curvature, elevation, sight distance, gradient, and landscaping. Harder road surfaces, particularly concrete and asphalt provide less resistance for rolling vehicles, requiring less energy in traveling over them. On softer road surfaces, such as dirt or gravel roads, vehicles expend a great deal of energy compressing the surface.

Roads and paths can be designed for energy efficiency, but constructing and maintaining these roads can be costly and energy inefficient. For example, concrete roads are the most energy efficient for vehicles, but they are also the most energy intensive during construction. Some recovered or substitute materials may be used in maintaining roads or paths. For example, asphalt ready to be torn up may be reused for resurfacing roads or laying new ones, while wood chips may be used for trails.

CONSERVATION MEASURES

The energy savings available in the transportation sector can be divided into savings that can be directly achieved by employees of refuges or hatcheries, and savings achieved by visitors or other non-employees. Although it is easiest to control the energy consumption of employees, the greatest energy savings potential lies in affecting energy use by visitors. Of course, visitor energy use cannot be recorded and monitored, nor do savings obtained by visitors show up as credits on the energy budget at the site. However, it is important that they be considered in developing plans to save transportation energy.

Energy conservation measures in the "Planning Process" section have been arranged according to five major conservation strategies which are discussed below.

Many of the examples given on the following pages are measures that can be implemented with little effort.

Reduce Travel Demand

The least costly means of saving energy is simply reducing travel. Cutting down on travel can be accomplished by foresight on the part of planners. Telecommunications can be substituted in some cases. By phoning ahead to make sure someone is in, unnecessary trips can be avoided. Instituting a reservation system for campgrounds can reduce wasted miles a visitor might travel looking for overnight accomodations. Some business may be carried out over the phone or by letter rather than by travel. Patrol cars can make speed checks with radar from a stationary position, instead of using driving patrols.

Improve Energy Conversion Efficiency of Existing Vehicles

All modes of transportation (except possibly bicycling and walking) can be made more efficient. To develop a strategy, you should begin by examining the least efficient modes and looking for potential improvements. For automobiles and trucks, regular maintenance can make a significant difference.

Driving for economy is a skill that can be improved in the average driver. Driver's training can remind drivers of energy saving ideas and techniques they may be overlooking. Driver's training should include instruction on handling the car, proper upkeep (such as keeping the tires inflated correctly), and planning trips ahead of time. Table 1 shows how gas mileage improves with driver's training. Descriptions of good driving techniques are provided in Reference (12).

Modification devices for existing vehicles can also produce energy savings. For instance, replacing bias ply tires with radials can increase auto mileage by one to two miles per gallon, and produce a fuel savings of up to 9.4% for trucks.(13)

Increase Load Factors

Load factors refer to the weight and volume that a vehicle carries. Truck operators can attempt to load a truck as close to capacity as possible. Loads of mixed materials or products can be put together to reduce the total number of trips required to transport large amounts of freight. Planning can reduce the number of empty miles driven at the site. Making one trip with a large vehicle to pick up many items from different places is usually more efficient than making many trips in a small vehicle to pick up one or two items at each place.

Shift to More Efficient Modes of Transportation

Switching to a more energy efficient type of vehicle can bring savings. (See Table 2.) For instance, using a bicycle or moped instead of a car or light truck to travel a mile between a visitor center and campgrounds can result in definite savings, especially over the long term.

You can only choose the right vehicle for the job if the vehicles are available to you. If they are not available, more efficient ones may be added when old vehicles are replaced. In choosing a new vehicle, overall performance should be a prime consideration.

The following factors affect a vehicle's gas mileage and overall performance, and contribute favorably to fuel economy:

1. Light weight
2. Radial tires
3. Manual transmissions (5-speed, overdrive)
4. More efficient engines (diesel, stratified charge)
5. Low axle ratios
6. Thermostatically controlled fans
7. Few power accessories.

Sometimes it is necessary to choose a less efficient vehicle because of the job to be done; because it performs better under certain weather conditions; because no alternative is available; or for other reasons.

Improve Usage Patterns

Energy can be saved by improving transportation usage patterns. A refuge or hatchery has a number of options in this area, including:

1. Reducing the number of speed changes and stops, so that drivers can maintain a steady speed to improve fuel economy
2. Closing roads to visitor vehicles and substituting bus service
3. Closing roads and converting them to trails or paths
4. Enforcing speed limits to reduce average speeds.

Employees can also take steps to save transportation energy. For example, taking the bus to work instead of a car can produce considerable savings over time.

PLANNING PROCESS

Often transportation-related measures to save energy are simple tasks requiring minimal investment of time and resources. A discussion of some of these simple, and other more complicated, suggestions is included here for your use in formulating your comprehensive transportation conservation plan.

TRANSPORTATION

Table 1 *Driver Training Gains (Source: Reference (11))*

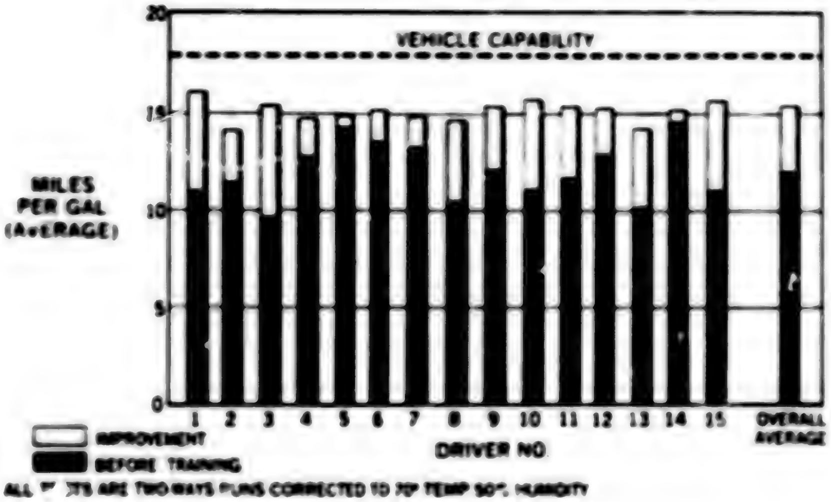
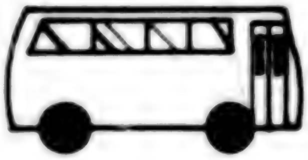
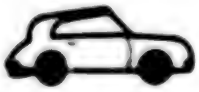


Table 2 *Typical Energy Efficiencies of Passenger Modes*

Bicycle	*Person on foot*	*Bus*	*Automobile*
			
97 BTU/passenger mile*	*500* BTU/passenger mile*	*3,000* BTU/passenger mile*	*6,700* BTU/passenger mile*

**These figures vary according to load factors, speed, efficiency of particular vehicle, road and weather conditions, and type of driving, among other factors.*

TRANSPORTATION

There are five overall strategies for conserving transportation energy. These are:

- reduce travel demand
- improve the energy conversion efficiency of existing vehicles
- increase load factors
- shift to more efficient modes of transportation
- improve usage patterns.

A four-step process is presented to enable you to choose which of these strategies are feasible for your refuge or hatchery. These four steps are:

Step 1. Familiarize yourself with the concepts on the proceeding pages concerning energy conservation in transportation

If you have not already read these sections you should do so before continuing. They will give you an overview of how energy can be saved in transportation; they explain how measures for this section are organized; and provide information that will help you to assess the measures.

Step 2. Collect fleet inventory data.

In many refuges and hatcheries, a list of vehicles and basic information about those vehicles already exists. In other sites, you will have to collect this information yourself. Use the form included as Transportation Data Form 1, Vehicle Inventory, p. 12, or your own listing if it contains all of the necessary date.

The information from this form will be used in several ways during the planning process. It will help you to identify vehicles which are particularly inefficient so that maintenance and operations efforts may be focused on them. It will provide information needed to answer questions involved in assessing specific measures, such as, "Are some vehicles not being used to capacity?" Could two such vehicles be replaced by a single vehicle? Which vehicles are ready for replacement? Could they be replaced by more efficient vehicles to serve the same purpose? Finally, the inventory will provide information required to evaluate the cost-effectiveness of various vehicle retrofit options.

Step 3. Select energy conservation measures from the group designated "I" on Worksheet I, Potential Transportation Conservation Measures.

Within each of the five conservation strategies for transportation there are measures which are designated "I" for "immediate priority." These operations and maintenance activities should be considered first by every refuge and hatchery.

Since these measures will enable you to realize considerable savings with little investment, the planning process can be streamlined to enable you to work through them very quickly, focusing on how to implement them rather than whether to implement them. It is unlikely that you will need to use the technical reference books. Further, it will not be necessary for you to complete 4 of the 10 columns on Worksheets II, Measures Evaluation. Specifically, the columns you may omit for this group of measures are:

- "potential benefits" - the major benefit from these measures (fuel savings) is self-evident.

- "first check point" - you will not need to make an initial judgment of barriers versus benefits.

- "savings" - savings for each of these measures will be difficult, if not impossible, to quantify. It will be more accurate to calculate the combined saving effect of these and other transportation measures by carefully monitoring fuel consumption over time.

- "payback period" - since costs are minimal and savings unknown for most of these measures, payback is not a useful concept. It can be assumed to be almost immediate where little or no cost is involved.

In filling out the remaining six columns you will concentrate on several questions:

- "Current Status" - Is this measure applicable? Has the refuge or hatchery already implemented the measure? Could implementation be improved?

- "Action Required for Implementation" - If the site has not already implemented the measure, what would be required for implementation - policy, training program, incentive program?

- "Barriers to Implementation" - Why hasn't the site implemented the measure already - motivation problems, unaware of its benefits?

- "Cost" - Are there any costs associated with the measure - staff time, training materials?

- "Training Needs" - Is training of staff needed to implement the measure? In what areas?

- "Motivation Problems and Incentives" - If motivation is a problem, what incentive could be offered to gain cooperation from staff?

Step 4. Select additional applicable measures and complete Worksheets II, Measures Evaluation.

After you have completed Step 3, you will be left with additional measures designated "H" for "high priority" and "F" for "further study.'

You should review the complete list of remaining measures and determine current status for each measure or group of measures. Measures in these areas generally have costs associated with them and will require a more detailed examination to determine their applicability and desirability.

These measures fall into two overall categories - those in which savings accrue to the refuge or hatchery, and those in which the savings accrue to visitors or staff as individuals. Vehicle modification is the major group in the first category, with additional minor savings accruing to the refuge or hatchery from measures in the areas of road maintenance and design. Although the refuge or hatchery will not realize energy savings from measures in staff carpools, visitor mass transit, bikeways and footpaths; there will be other benefits for the site such as reduced population, less traffic congestion, fewer parking problems, and setting an example for the public. Further, energy savings will result for the staff members or visitors involved, and for the community as a whole.

TRANSPORTATION

Clearly, a decision must be made whether to spend money on measures which will not result in direct energy savings for the refuge or hatchery but which will have a significant conservation impact outside the site. You want to make a decision on this question at this point, or you may prefer to evaluate the various measures and make recommendations to your administrators. If you choose to consider any of these additional areas, you should read the special instruction below.

Vehicle Modification -- In assessing the desirability of purchasing and installing energy saving devices for vehicles, the most important consideration is cost-effectiveness. However, you must also consider how long you plan to keep the vehicle in question. For example, if installing a "widget" in the site's pick-up truck was found to have a simple payback period of 3 years, this would normally be considered a good investment. But if you plan to replace the vehicle in 2 years, then this investment no longer makes sense.

Staff Carpools -- Assessing staff carpooling will require you to consider the number of staff, dispersion of their homes and work places, and their schedules. A large map with colored pins might be helpful in conducting this assessment.

Visitor Mass Transit -- If there is no visitor mass transit system now in your refuge or hatchery, you will probably want to call in expert assistance after you have conducted a preliminary assessment of potential benefits and barriers. The number of visitors and vehicles and their travel patterns within your site will be important initial factors to consider. This section also includes measures aimed at improving existing mass transit systems.

Bikeways and Footpaths, Road Maintenance and New Road Design -- Since these sections may have significant cost and environmental implications, you may want to obtain technical assistance after you have considered potential benefits and barriers. This area is also tied very closely to site design.

A sample completed Worksheets II, Measures Evaluation, is included following the list of potential conservation measures.

After you have completed a list of potential conservation measures for this section and have completed your Worksheets II, Measures Evaluation, you should review the material in the Introduction which explains how to pull all of your measures together into a comprehensive Energy Conservation Management Plan.

REMEMBER: The measures you are considering for transportation are meant to be a part of your total plan.

Data Form 1

VEHICLE INVENTORY								
Vehicle Type	Make	Model Year	Current Odometer Reading	Average Daily Milage	Average Miles/ Gallon	Annual Fuel Costs	Expected Replacement Date (Year)	Use

WORKSHEET I
POTENTIAL TRANSPORTATION CONSERVATION MEASURES

WORKSHEET I

TRANSPORTATION MEASURES

Measures	Current Status	Technical Reference**
1. REDUCE TRAVEL DEMAND		
1.1 Increase use of telephone or written communications instead of travel. I*		
1.2 Plan trips and select fuel-saving routes. I		
2. IMPROVE ENERGY CONVERSION EFFICIENCY OF EXISTING VEHICLES		
2.1 Service Vehicle Maintenance		A Guide to Reducing, pp. 46-9; 350 Ways, pp. 179-192
(a) Establish preventive maintenance schedules and checklists. I		
- Maintain proper tire pressure.		
- Change oil and filter at recommended intervals to reduce engine wear and maintain low oil and fuel consumption.		
- Check and replace spark plugs regularly.		
- Maintain wheel bearings and braking systems to reduce friction losses.		
- Replace worn points and wires, and maintain proper timing.		
- Keep air pollution equipment free of sludge and other material.		
- Clean and adjust carburetor periodically.		
- Keep choke and throttle clean and well lubricated.		

* I indicates immediate priority measures which should be considered first.

** These references are part of a core library which should accompany these energy conservation/management planning materials.

WORKSHEET I

TRANSPORTATION MEASURES

Measures	Current Status	Technical Reference
- Check wheel alignment frequently.		
- Maintain correct belt tension.		
- Keep radiator free of clogging material.		
- Check for and remove blockages in exhaust systems.		
(b) Recycle used oil. I		Decision Makers, pp. [illegible] 145
(c) Recharge batteries on electrical equipment during off-peak demand periods. I		
(d) Implement a vehicle monitoring policy to ensure vehicles are attaining mandated mileage performance goals based on Operator's Record or other forms. I		Energy Mgmt., pp. 9-15
(e) Install evaporative limiters (nozzles) on gas pumps. I		
2.2 Service Vehicle Operation		
(a) Train staff to employ fuel efficient driving techniques. I		350 Ways, pp. 133-160.
(b) Do not carry unnecessary weight. I		350 Ways, p. 151
(c) Do not overfill gas tanks. I		350 Ways, pp. 182-3
(d) Use lightest vehicle appropriate for each trip. I		
(e) Encourage staff to report any malfunction or increase in gas consumption immediately. I		

WORKSHEET I

TRANSPORTATION MEASURES

Measures	Current Status	Technical Reference
(f) Use ice scrapers for cleaning snow and ice from car windows instead of long warm-up periods. I		
(g) Encourage staff to avoid using the air conditioner. I		350 Ways, pp. 166-7
2.3 Boat and Aircraft Maintenance and Operation (if applicable)		
(a) Clean marine growth from boat hulls to reduce drag. I		Energy Saving Guidebook, pp. 96-7
(b) Use smaller motors on boats. I		
(c) Keep boat motors tuned. I		
(d) Improve aircraft skin maintenance to reduce drag. I		
2.4 Service Vehicle Retrofit		
(a) Use radial tires. H *		350 Ways, pp. 167-170
(b) Add air shields to trucks that travel at highway speeds to reduce aerodynamic drag. H		Trucker's Guide, pp. 9-10
(c) Install a clutched or demand fan in trucks. H		Energy Mgmt., pp. 29-31; Trucker's Guide, p. 11
(d) Remove or disconnect unnecessary comfort accessories (such as air conditioners). H		350 Ways, pp. 166-7
(e) Install carburetor systems that permit "lean" operation (air-fuel ratio = 18-20). H		Highway Vehicle, Vol. I, pp. 3-1 to 3-77, 3-104 to 3-115
(f) Install inlet manifolds with reduced flow cross-sectional areas which increase the flow velocity		Highway Vehicle, Vol. I, pp. 3-156 to 3-175

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* H indicates high priority measures which require significant investment but are certain of economic payoff.

WORKSHEET I

TRANSPORTATION MEASURES

Measures	Current Status	Technical Reference
of the fuel-air mixture in the manifold and improve fuel distribution. H		
(g) Install capacitive discharge or electronic inductive ignition systems, particularly in vehicles with lean air-fuel ratio settings. H		*Highway Vehicle*, Vol. II, pp. 4-6 to 4-7
(h) Change the rear axle gear ratio. H		*Highway Vehicle*, Vol. II, pp.6-8 to 6-10
(i) Add an overdrive unit. H		*Highway Vehicle*, Vol. II, pp. 6-15 to 6-19
INCREASE LOAD FACTORS		
3.1 Deliveries and Staff Travel		*Trucker's Guide*, pp. 6-7
(a) Plan vehicle use to maximize vehicle payloads. I		
(b) Consolidate deliveries and other travel. I		
3.2 Staff Carpools		*Guide to Reducing*, pp. 23-4
(a) Provide written materials about transportation alternatives to staff (carpools, vanpools, buses, etc.). I		
(b) Establish carpooling incentive programs for staff. I		
(c) Establish "park and ride" lots. I		
(d) Provide preferential parking for staff carpools. I		
(e) Provide preferential traffic control for carpools. I		

WORKSHEET I

TRANSPORTATION MEASURES

Measures	Current Status	Technical Reference
4. SHIFT TO MORE EFFICIENT MODES OF TRANSPORTATION		
4.1 Existing Fleet		Energy Effects, pp. 14-33
(a) Use small trucks instead of large trucks unless the number of trips required to do a job would be increased. I		
(b) Use cars instead of trucks whenever possible. I		
(c) Use small cars instead of large cars. I		
(d) Use motorcycles, mopeds, bicycles instead of cars. I		
(e) Walk instead of driving short distances. I		
4.2 Replacement Policy		
(a) In purchasing new vehicles, consider factors contributing to fuel economy such as: smaller, lighter vehicles - smaller engines - fewer comfort and power accessories (air conditioning, power steering, automatic transmission). H		350 Ways, pp. 161-178
(b) In purchasing trucks, consider factors contributing to fuel economy such as: powered and unpowered tandem rigs - single axle drive - clutched or demand fans. H		Energy Mgmt., pp. 22-33
(c) Retire unnecessary vehicles. H		
(d) In purchasing new boats, select those with more efficient hull designs and smaller motor requirements. H		

WORKSHEET I

TRANSPORTATION MEASURES

Measures	Current Status	Technical Reference
4.3 Visitor Mass Transit		
(a) Implement or expand visitor mass transit system within the site. F *		
(b) Improve quality of the mass transit system within the site including comfort, frequency, and convenience. F		
(c) Provide mass transit for visitors between the site, and nearby cities, towns, airports, or "park and ride" lots. F		
4.4 Bikeways and Foot Paths		
(a) Establish visitor comfort stations or sheltered rest areas for bicycle riders and hikers. H		
(b) Expand and improve foot paths and trails. H		
(c) Install bicycle and pedestrian activated traffic signals. H		
(d) Designate exclusive bikeways, or bikeways on existing rights of way. H		
(e) Install bicycle racks and moped/motorcycle parking areas. H		
(f) Provide inexpensive bicycle or moped rentals. H		
5. IMPROVE USAGE PATTERNS		
5.1 Traffic Flow		
(a) Improve traffic flow and encourage steady vehicle speeds by reducing speed changes and stops. I		

* F indicates measures which require further study to determine their economic feasibility.

WORKSHEET I

TRANSPORTATION MEASURES

Measures	Current Status	Technical Reference
(b) Reduce travel speeds and enforce speed limits. H		
(c) Establish auto-free zones (pedestrian, bicycle, or mass transit only). H		
5.2 Road Maintenance		
(a) Curtail nonessential highway maintenance, such as some right-of-way mowing. I		
(b) Use less energy intensive materials for road repairs (use asphalt cold mix, emulsions, flyash where feasible). I		
(c) Reduce unnecessary lighting in roadways. I		Street Lighting, pp. 16-20
(d) Recycle waste asphalt. I		
5.3 New Road Design		
(a) Reduce gradients. F		
(b) Minimize need for speed changes. F		
(c) Use less energy intensive construction materials. F		
(d) Reduce highway lighting. F		

Worksheet II: Measures Evaluation

Measures	Potential Benefits	Action Required for Implementation	Barriers to Implementation	First Decision Point
2.4.d. Remove or disconnect air conditioners	● Gasoline savings ● Set a good example for visitors	● Minor mechanical operation	● Staff morale would suffer ● Staff efficiency and performance would suffer	Stop
2.4.f. Install "widgets" on 7 vehicles in fleet (see Vehicle Retrofit Feasibility Worksheet)	● Gasoline savings	● Vehicle retrofit	● None	Go on
3.2 Initiate staff carpooling system	● Reduce traffic congestion and noise ● Reduce pollution ● Relieve overcrowding in parking lots ● Staff save money on gasoline ● Overall energy savings	● Policy ● Incentive program	● Motivation problems ● Schedule conflicts	Go on

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Page

Worksheet II: Measures Evaluation (Part II)

Cost	Savings (\$ and BTUs)	Payback Period	Training Needs	Motivation Problems and Incentives
\$250 each x 7 vehicles = \$1,750	18%	Less than 3 yrs. - see Vehicle Retrofit Feasibility Worksheet	None	None
Minimal - staff time to organize program Bulletin board to help arrange carpools	Park does not receive savings - staff will get savings			• Motivation problems - private cars are more convenient and people are used to having them • Incentives - education on value of energy savings - reminder of dollar savings on gas - establish preferential parking areas

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*Core books from other section of the Planning Guide.

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*CORE SOURCES (Waste Management)

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ABSTRACTS

Core Sources

Energy Effects, Efficiencies, and Prospects for Various Modes of Transportation, National Cooperative Highway Research Program 43, Wash., D.C.: National Academy of Sciences, Transportation Research Board, 1977.

This study provides excellent background material on energy use in all transportation modes. Using numerous charts and graphs supplementary to the text, the work compares energy use by various modes as well as comparing transportation to other energy users.

Potential impact of energy conservation options are presented in a detailed, thorough matrix. Comparison of various modal shifts are made using a systems approach. The concise summary of conclusion and recommendation offers some excellent suggestions for transportation conservation in both the short and the long term.

Energy Management in Municipal Vehicles, Boston: Massachusetts Dept. of Community Affairs, 1977.

This study provides all the necessary information to implement an energy management plan for a fleet of vehicles. It includes reproducible worksheets and forms that, when used as described, could yield major savings in energy.

After an overview of the impact of the energy crisis on fleet costs, the study outlines and completely describes five elements of an energy management scheme. Namely,

- fuel and maintenance cost accounting
- life cycle costing
- preventive maintenance
- reduced vehicle usage
- vehicle replacement

In addition to providing excellent baseline data on fleet costs, the study gives case studies of cities that have implemented successful energy management plans.

A Guide to Reducing. . .Energy Use, Budget Costs, Wash., D.C.: The National Association of Counties, 1977, Chapts. 3 & 4.

This document provides information needed to tailor an energy conservation program to a specific community. It is divided into three major sections that deal with the "whys," 'hows," and "by whoms" of energy conservation. The work is implementation oriented and categorizes energy saving improvements both in terms of costs and payback period.

Chapter 3, entitled "Employee Programs," offers suggestions on increasing energy conservation awareness among employees and focuses on employee transportation modes including mass transit, car pooling, and other energy efficient methods of travel. Successful energy conservation schemes are provided.

Chapter 4, entitled "Vehicle Fleets," covers most substantive areas of operation, procurement, and management of an energy efficient fleet. Appendices include useful information on car sizing policies, fuel rationing plans, preventative maintenance checklists, and baseline information on dieselization, radial tires, and optimum routing schemes.

Highway Vehicle Retrofit Evaluation. Phase I. Analysis and Preliminary Evaluation Results, Cambridge, MA.: Transportation Systems Center, 1975, 221 pp.

This two-volume report presents an analysis and preliminary evaluation of selected used-car and light-truck fuel economy retrofit devices. In particular, performance characteristics of retrofit devices with the potential to improve automotive fuel economy are presented. The devices include carburetors, acoustic and mechanical automizers, lean-bleed devices, vapor injectors, fuel modifications, inlet manifolds, drivetrain components, drag reduction techniques, driver aids, cooling fans, valve timing, tuneups, exhaust-related systems, engine oils, oil additives, and filters.

Trucker's Guide to Fuel Saving, Wash., D.C.: Federal Energy Administration, Dept. of Transportation, Environmental Protection Agency, 1976.

An excellent "how-to" brochure designed for the fleet manager and operator, this booklet suggests energy conservation actions, both through operational changes and vehicle retrofit. Sample topics include: engine-tuning, diagnosing chassis problems by measuring tire wear, and add-on equipment, such as temperature modulated furs and turbo-charging kits. This booklet is non-technical, to the point, clear and provides a summary of energy conservation in heavy trucks which makes it required reading for those involved in transportation.

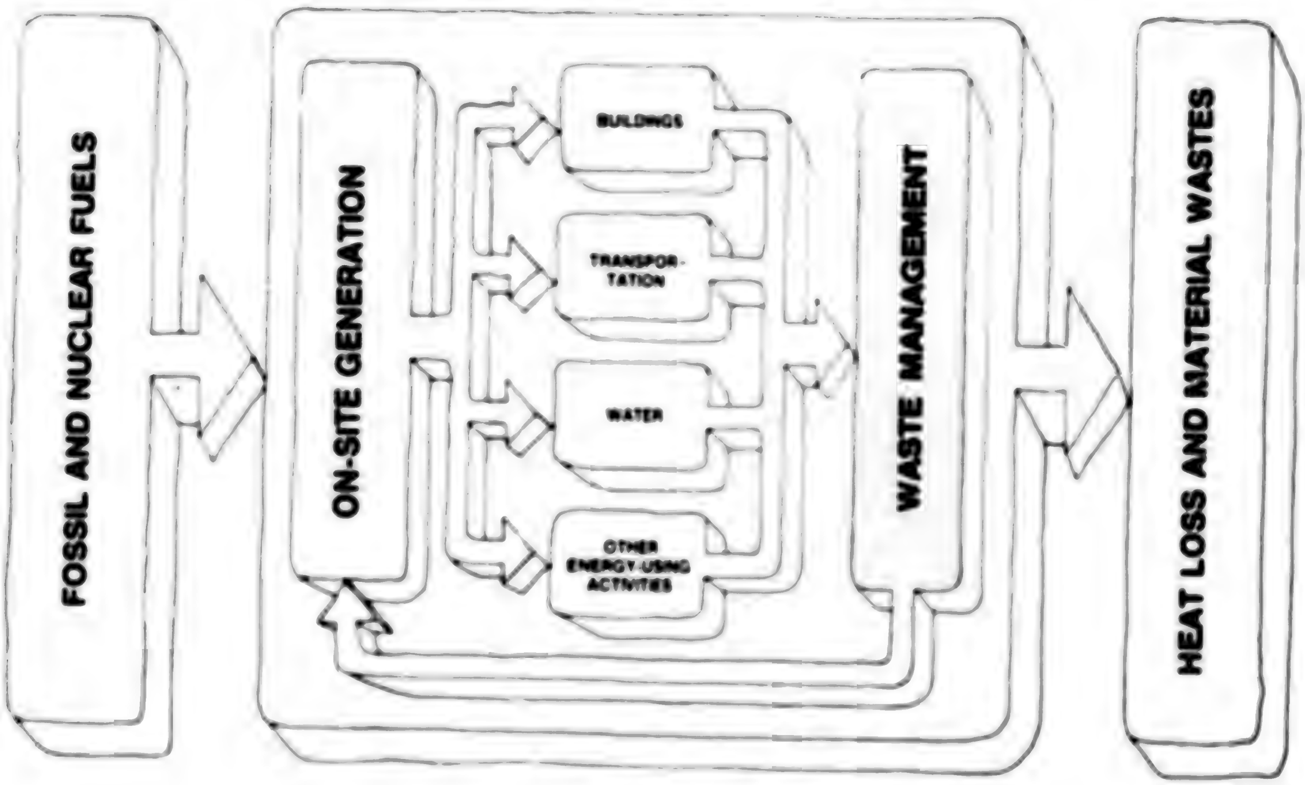
350 Ways to Save Energy (And Money) In Your Home and Car, Henry R. Spies, Seichi Konzo, Jean Calvin, & Wayne Thoms, New York: Crown Publishers, Inc., C. 1974, pp. 133-192.

TRANSPORTATION

Many valuable tips are offered for saving energy in the home, but of particular interest are ways for improving energy consumption in cars. This comprehensive guide covers: driving for economy, including mountain driving, cold starting, use of gears, route planning, weather conditions, driving techniques, among others; choosing the right car and equipment, including power accessories, tires, emission controls, grade of fuel, the electrical system, vacuum guages, and the fuel filter; and tuning and maintenance, including tune-up tips, when to fill up the tank, fuel leak inspections, tire and chassis maintenance, and fuel and oil additives.

Waste Management

VOLUME I
BOOK 4



SITE ENERGY-USING FUNCTIONS

This section on Waste Management is part of a two volume Planning Guide designed to help its readers formulate an overall site-specific Energy Conservation Management Plan. It provides you with technical information about waste handling as well as instructions for choosing and developing measures designed to save energy by dealing with waste more efficiently.

WASTE MANAGEMENT

WASTE MANAGEMENT AS AN ELEMENT OF THE SITE

The word waste refers to the unwanted or unplanned by-products of any activity or process. Wastes are energy and materials discarded in the course of daily activities. The laws of physics tell us that there is no way to completely eliminate waste, since there is no such thing as a process which is 100% efficient. But for practical purposes, we can say that a great deal of waste is the result of poor planning. The purpose of this section is to help you reduce waste and improve the efficiency of waste management processes. This can help you achieve your primary goal of saving energy while also protecting the local environment, and saving money and valuable material resources.

Waste management must be an integral part of every element of the FWS energy conservation program and will only be effective if given equal priority when mapping out strategies for each of the sections dealing with buildings, transportation, etc. For waste conversion systems are actually on-site generation processes with wastes serving as the renewable resource.

Energy-Using Systems for Waste Management

The waste management system at a site shares the characteristics of other energy-using systems. It requires energy inputs, in the form of gas, diesel fuel, and liquefied petroleum gas to run trucks and tractors. Electricity is used to power much of the equipment and to provide heat and light for treatment or conversion processes. The energy-using components and systems for managing waste at the site level include vehicles, conversion systems, disposal sites, and disposal units. These systems are used to provide the desired functions of waste collection, conversion, and disposal. In some cases, waste conversion systems can also produce energy, thereby improving the efficiency of the overall system. In Figure 1, energy inputs in the form of gasoline and natural gas are used to power the components of a waste management system. The gas fires an incinerator, used to dispose of trash collected from locations around the site by a garbage truck. Both elements of the system offer opportunities for improved energy efficiency.

In the planning process section, measures for energy conservation in waste management systems are grouped into four strategies:

1. Reduce waste,
2. Improve the energy efficiency of waste handling procedures and equipment,
3. Recover and recycle waste materials,
4. Convert waste materials into useful products or energy.

After a short discussion of the most common types of waste, the desired functions of waste management systems and their components, these strategies will be developed more fully.

Types of Waste

Virtually all types of waste can occur at refuges and hatcheries.

WASTE MANAGEMENT

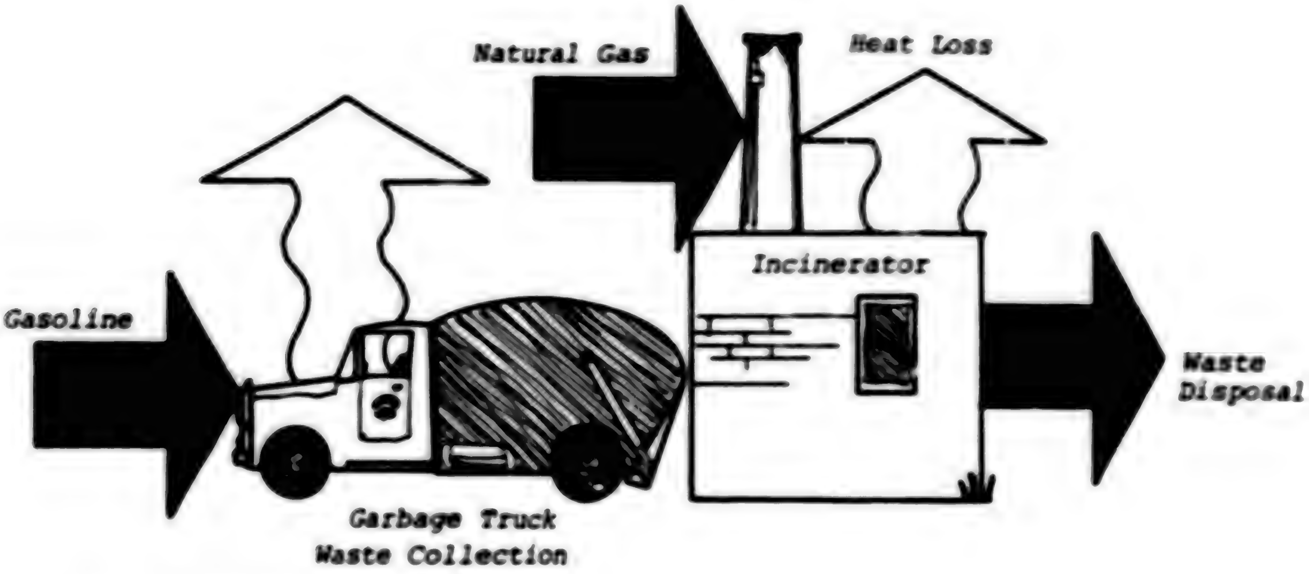


Figure 1 *Energy Flow*

Table 1 shows the most frequently found types of waste, and briefly describes their content and the usual methods employed to dispose of them. Not all of the wastes displayed in Table 1 are common, however; for example, it may be unusual to find pathogenic chemicals in the solid waste handled at the typical refuge or hatchery. By contrast, organic solid waste may be a major problem. Figure 2 displays the relative percentages of different types of municipal solid waste in 1975. It is interesting to note that 78.5% of U.S. solid waste in that year was combustible--much of it a potential energy source.

Desired Functions

Major tasks involved in waste management are the collection, conversion and disposal of wastes.

Collection

Beginning its journey through the site waste management system, waste is collected through mechanical means, sewage treatment systems and other techniques. In the collection phase, the volume of wastes is sometimes reduced by shredding, chopping or grinding by machines at the disposal site or in the trucks used to collect the waste.

Disposal

Wastes are most frequently disposed of in open dumps, an energy efficient but potentially unsanitary technique. Other methods widely used in this country are incinerators, sanitary landfills, dumping at sea, and the simple expedient of leaving wastes uncollected. Figure 3 shows how many million tons of waste were disposed of by each of these methods in 1969. Open dumps certainly do not

WASTE MANAGEMENT

Table 1 *Waste Types and Disposal Methods*

TYPE	*CONTENT*	*DISPOSAL METHOD*
Human waste	*Excrement* *Other*	*Sewage system*
Animal	*Excrement* *Pathological*	*Uncollected* *& Trash*
Agricultural	*Grain/grain straws* *Wood (chips, fire logs, pulp, waste)*	*Recycled, Uncollected* *& Trash*
Aqua/mari-Cultural	*Biological* *Botanical* *Man-produced (fishery/boat wastes)*	*Uncollected* *& Trash*
Solid waste	*Trash* 1. *Organic (pathogenic/non-pathogenic)* a. *Biodegradable/non-biodegradable* b. *Combustible/non-combustible* 2. *Inorganic (pathogenic/non-pathogenic)* 3. *Rubber* 4. *Metals (ferrous/non-ferrous)* 5. *Glass* *Industrial (machine turnings/flashings)* 1. *Metals (ferrous/non-ferrous)* 2. *Plastics (biodegradable/non-biodegradable)* *Chemicals* 1. *Toxic* 2. *Non-Toxic* 3. *Pathogenic*	*Trash,* *Uncollected,* *Special disposal* *& Recycling*
Liquid waste	*Chemical* *Toxic/non-toxic* *Pathogenic* *Water*	*Sewage* *Special disposal* *Evaporation*
Heat		*Uncollected*

WASTE MANAGEMENT

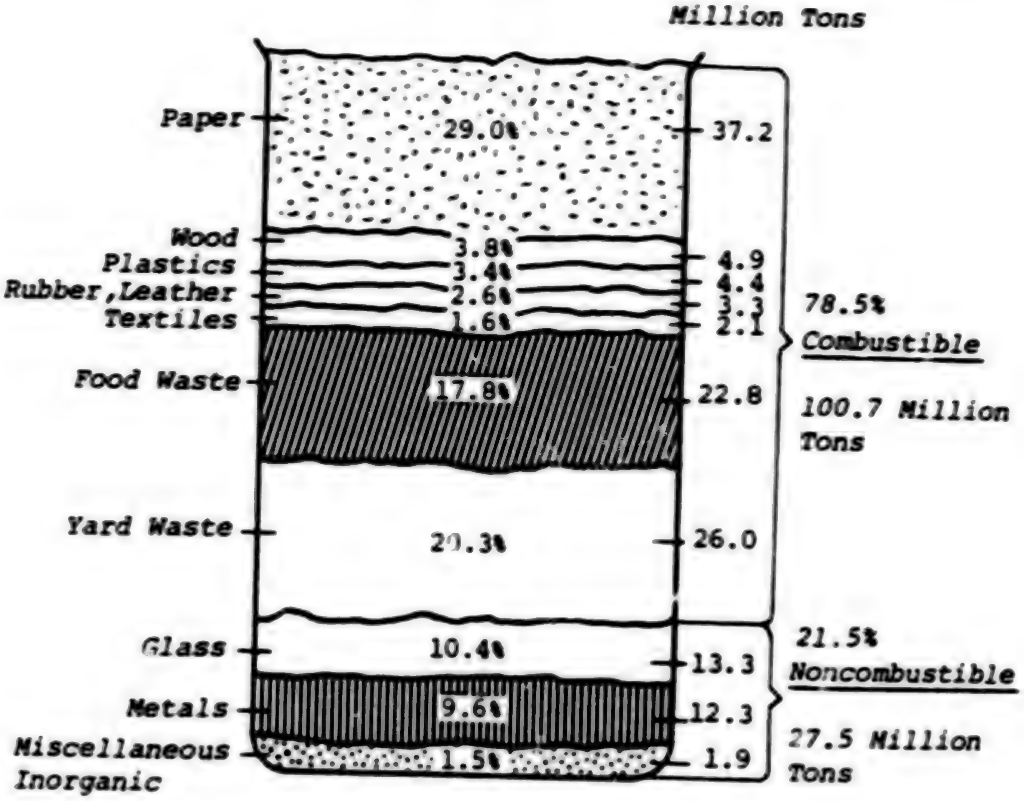


Figure 2 *National Trash Can (Annual Municipal Solid Waste - 1975) (Source: Reference 1)*

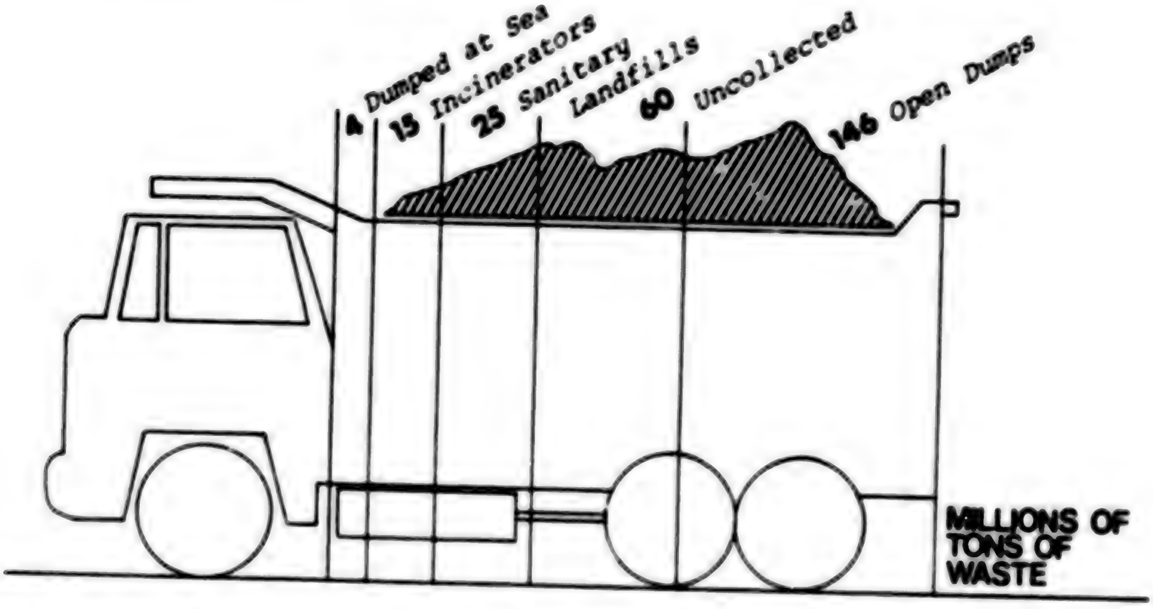


Figure 3 *Methods of Waste Disposal in the United States (1969) (Source: Reference (2))*

blend with the scenic beauties of an FWS site. Sanitary landfills offer an alternative, although for landfills outside site boundaries, energy is needed to transport wastes for disposal. Precautions must also be taken in operating a landfill to control liquid and gaseous by-products, since methane and hydrogen sulfide gases can be toxic. Frequently, wastes at refuges and hatcheries may also fall into the "uncollected" category. The substantial acreage and lack of easy access at some sites make collection difficult or virtually impossible in some instances.

Conversion

Energy can be recovered from waste through conversion processes. Systems for this purpose are discussed below, under the strategy for converting waste materials into useful products or energy, and in the Biomass section of Volume II, On-Site Generation.

Energy Costs and Credits

Each stage in the waste management process involves energy transfer. Knowing the energy costs and credits for each stage of the process will help you to devise a strategy for improving energy efficiency. Table 2, developed by the Portland Recycling Team, identifies these costs and credits. For instance, the disposal of wastes by users involves minimal energy costs in Btu per ton of refuse handled. However, recycling of materials by individuals may be very expensive in energy terms. Energy costs begin to rise in the initial processing stage, and become particularly steep for additional transportation and final processing. At the final processing site, however, energy may actually be recovered, using such systems as pyrolysis, recycling, composting, and burning refuse-derived fuel. Using other systems, particularly incineration, may involve enormous energy costs. For example, at the final processing stage, recycling recovered materials may yield 12,335,400 Btus per ton while incineration will result in a loss of 63,500,000 Btus per ton.

STRATEGIES FOR ENERGY CONSERVATION

Reduce Waste

Americans tend to be free with their throwaways. In 1975, Americans threw away 8 million tons of newspaper, nearly 3 million tons of paper products such as napkins and paper plates, more than 2 million tons of major appliances, 22 million tons of food and over 46 million tons of packaging.(4) By throwing away these materials, Americans also threw away much of the energy used to create them. When waste is reduced, overall use of energy also goes down.

Identifying major sources of your waste and then working to reduce them can be an important energy saver that may involve little or no cost. To develop this strategy, it is helpful to know what is being discarded. Does the site waste stream contain many disposable items or products contained in useless packaging materials? Purchasing products with longer lifetimes or reusable products rather than disposables will reduce replacement needs and disposal problems.

Because GSA supplies U.S. government sites with many products, there may be some constraints on the extent

Table 2 *Energy Costs and Credits of Refuse Disposal Subsystems*
(Thousands of Btu per ton)
(Source: Reference (3))

Stage	Sub-System	Energy Costs	Energy Credits	Net Energy Yield
User disposal	Home disposal	negligible	0	0
	Home separation of recyclables with truck pick-up and delivery to recycling center	8.4	0	-8.4
	Home separation of recyclables with auto delivery to recycling center	428.0	0	-428.0
Initial transport	Truck haul, 10 miles	94.6	0	-94.6
Initial processing	Landfill of waste	73.0	0	-73.0
	Handpicking of cardboard	negligible	0*	0
	Shredding	175.6	0*	-175.6
	Magnetic separation	13.1	0*	-13.1
	Air classification	39.0	0*	-39.0
	Baling	142.1	0	-142.1
	Hand separation at recycling center	175.7	0*	-175.7
Additional transport	Haul to processing center, 80 miles	435.4	0	-435.4
	Haul to final processing, 10 miles	62.5	0	-62.5
Final processing	Incineration	63,500	0	-63,500
	Waterwall incineration**	63,500	13,550	-49,950
	Electrical generation with steam-turbine	64,234	23,692	-40,542
	Pyrolysis	779.6	5,000	+4,220.4
	Recycling of recovered materials	1,370.6	13,706.0	+12,335.4
	Recycling cardboard	6.6	66	+59.4
	Firing refuse-derived fuel (RDF) in existing boilers	0	9,200	+9,200
	Composting and methane recovery	842.2	15,713	+14,870.8
	Fiber recovery	1,200	3,200	+2,000
	Landfill of residue	73	0	-73

*Energy credit of recovered materials in final processing section.
**These values assume a 400 ton-per-day incinerator producing 100,000 pounds of steam per hour.

to which these measures can be implemented, although the strategy is worth encouraging.

Improve the Energy Efficiency of Waste Handling Procedures and Equipment

Transportation of waste consumes energy in both the collection and disposal stages of waste handling, and may be made more efficient in many ways. Vehicles should not be oversized in relation to the amounts of waste they collect. In some cases, gasoline or diesel-powered trucks may be replaced with horse-drawn carts. Careful evaluation should be made of special equipment needed in vehicles used for both collection and disposal. For example, the energy used by collection vehicles for shredding, chopping and grinding will allow wastes to be packed and transported more efficiently. Also, by producing high density wastes, overall energy costs for transportation and disposal may be reduced. If wastes are to be converted to energy, compaction equipment may be needed. Disposal methods such as open dumps and sanitary landfills require use of tracked crawlers or tractor-type spreaders. When these vehicles are selected, energy use should be carefully plotted with the function the equipment is intended to serve.

Knowing how much and what kinds of waste are generated by employees and visitors is also important in developing an energy-saving program. Noting seasonal variations can improve the energy efficiency of collection. Planning routes to save on mileage can save gasoline. Furthermore, if recycling is being introduced (see below) or if recycling efforts are being stepped up, some method for separating recyclables from regular wastes may be needed. If recyclables are collected separately, the volume of wastes will be reduced, which may in turn allow use of smaller vehicles.

Recover and Recycle Waste Materials

As it becomes necessary to drill deeper and deeper for oil and ores used in the production of metals and travel farther from refineries/mills to extract these resources, more energy must be expended to produce the finished products from the raw material. It takes much less energy to produce aluminum and other metals from scrap than from virgin ore. The same is true of glass and may someday be true of new recyclable plastics. Therefore, recycling may become an important and necessary method for conserving the nation's energy. Recycling of paper, wood, glass, metals, rubber, and certain types of plastic waste products, while not necessarily contributing to the conservation of energy in the site, may benefit a larger system -- the country as a whole.

The method used for collecting recyclables is critical to overall energy savings. Separation of recyclables from wastes at the source and use of energy efficient vehicles can help make recycling cost-effective. That is, the overall recycling energy costs should be less than the costs for producing products from raw materials. Some recycled products, particularly aluminum cans, have a monetary value, so the site may have the opportunity to make money while saving energy. Some materials can also be reused without much processing, such as wood chips for trails and asphalt for roads.

WASTE MANAGEMENT

Convert Waste Materials into Useful Products or Energy

Wastes often represent valuable resources, and can be used as the raw material for systems and processes that produce useful products or energy. If this can be accomplished, wastes become an energy input of value to the system and improve its overall efficiency. However, considerable caution is needed in planning a strategy of this kind. Potential for recovering energy from waste is sometimes overestimated. The usability or marketability of recovered energy or products must be considered. For instance, if low grade fuels are recovered from agricultural wastes, will the fuels be useful in site operations, or meet some off-site demand? If neither result applies, there may be no reason to implement the conversion system. Also, most conversion systems, to operate efficiently and cost-effectively, require large, steady volumes of waste. Most sites do not generate enough waste for them to be practicable.

Energy released by conversion processes may be used: 1) directly in the form of electricity or heat, or 2) indirectly in the form of products that generate energy through indirect means, such as the use of fertilizer to help plants grow. The plants serve as food for animals and humans. In turn, animals and humans use this energy to do work.

There are two major categories of available conversion systems -- thermal systems and biological systems. Thermal systems demand heat to burn wastes or convert them to fuels. In biological systems, organic decomposition occurs.

An introduction to different types of systems and processes in each category is given below. Some of those introduced here are handled more fully in other sections of the materials.

Thermal Systems

Available thermal systems include incinerators and pyrolitic converters, which are discussed at greater length in the Biomass section of Volume II, On-Site Generation.

Conventional incineration systems are heavy users of energy, but can be modified or replaced with components or systems that capture the energy released in combustion for a useful purpose. Incinerators need electricity for charging and control facilities, lighting, and power for fans, pumps, cranes, air pollution devices and other equipment.(5) Larger plants also draw energy to supply services for the personnel that run them, such as drinking water, heating and hot water, and sanitary facilities.

Incinerators dispose of wastes by reducing them to ash (an excellent source of nitrogen for agricultural purposes) with waste heat escaping in the process. By attaching one of the many types of heat exchangers, the heat produced by the incinerator can be used to heat water and supply nearby buildings with hot water and space heat. The large amounts of waste heat produced by incinerators may also be used to produce steam, which can be used to turn generators to supply electricity to the site. The composition of wastes, which varies with the season, affects both the heat content of refuse and the energy that must be supplied during the combustion operation. Variations in composition should be taken into account when designing such a system or its add-on units. An optimum furnace temperature should be maintained.

Pyrolitic converters can convert many wastes that would otherwise be difficult to dispose of, especially agricultural wastes, into efficient fuels. Pyrolysis is the chemical decomposition of wastes in the absence of oxygen. Materials such as peanut hulls, sawdust, and wood waste that are inefficient fuels in their natural state can become efficient fuels when burned in an oxygen-starved environment and compressed into charcoal-like briquettes. At the same time, pyrolysis converts these wastes into a low Btu gas and a heavy tar-like oil which has a lower Btu value than ordinary fuel. Where the right type of waste is in abundant supply, the pyrolytic method can be energy conserving. Pilot plants for this conversion method have been in operation for a long time. They have effectively demonstrated the ability of these systems to produce more energy than they consume.

Biological Systems

Several types of biological conversion systems are worthy of interest, including composting, anaerobic and aerobic digestion, the new CANWEL system under development in Canada, enzymatic and acid hydrolysis and biological toilets. Anaerobic digestion, a process that has many potential applications at NPS and FWS sites, is covered more fully in the Biomass section of Volume II, On-Site Generation. Biological systems for wastewater treatment are also discussed in the section on Water Conservation.

Composting is the biochemical decomposition of organic solid wastes which produces a humus-like substance used for soil conditioning. Composting can occur outdoors using a mechanical system. Five basic steps are involved in composting: preparation, digestion, curing, finishing, and storage or disposal.(6) Organic wastes must be separated from noncompostable wastes. Then shredders, grinders, and choppers can be used to prepare wastes for digestion. Digestion can occur when the refuse is ground and moistened and then conveyed to an outdoor decomposition area. Compost is then cured and dried. If needed, it is finished by regrinding and screening. Finally, it is marketed or put to use.

Composting can be performed in simple compost piles outside a building or in a complex mechanical system requiring a building and heavy equipment. To decide whether or not composting would be beneficial to a site, a close look should be taken at potential uses for the finished product because compost is not easily marketed.

Composting processes are best located in rural areas, although some municipalities are investigating the possibilities of landfill-size compost piles. In this variation, deep trenches are dug to hold the trash, earth is used for cover, and the trash is left to sit for specified periods of time. The compost produced is then scooped out, packaged and sold as a humus-type soil conditioner.

Some caution is necessary in dealing with the anaerobic digesters which produce methane gas and its derivative, methanol, as well as high-quality fertilizers and solid fuels. Agricultural, aquacultural, and some industrial wastes can be effectively managed in an energy conserving and productive manner.

Aerobic digesters require oxygen from the air for conversion action to occur. Oxygen is made available throughout the system by stirring the dry wastes or bubbling oxygen through the wet slurry. (If sufficient oxygen is not available, the system becomes anaerobic.) The aerobic system produces usable solids (fertilizer) and water. These systems normally operate at higher temperatures than anaerobic systems. Therefore, they kill pathogenic bacteria and other internal organisms much more quickly. Some technical and practical problems remain to be solved before these systems will be readily available.

A household waste disposal system called CANWEL (Canadian Water Energy Loop) has been designed to treat sewage and household garbage. It has definite possibilities as an energy saver because it cleans and recirculates wastewater for low quality use in toilets or high quality use in drinking and cooking water.(7) Using an incineration process, sewage sludge and kitchen garbage are burned, and the heat that is generated is used to supply hot water.(8) A prototype CANWEL system has been operating successfully at the Ontario Research Foundation, Sheridan Park, Mississauga, Ontario for 2 1/2 years.

There are two hydrolysis methods available for converting organic cellulosic wastes to energy: enzymatic hydrolysis and acid hydrolysis. Enzymatic hydrolysis is a method for using enzymes to break down wastes into sugar, which can be converted to alcohol (ethanol). Acid hydrolysis uses acid rather than enzyme with the same end results.

Table 3 shows the advantages and disadvantages of both enzymatic hydrolysis and acid hydrolysis. In the future, some sites may be able to use hydrolysis processes to convert wastes into energy.

Biological systems have been developed to handle toilet wastes. These systems require the addition of bacteria and enzymes periodically to turn wastes into water. The water is then recirculated to the toilet.(12) Biological toilets are energy saving, and they have the added benefit of conserving water.

PLANNING PROCESS

To implement the concepts just discussed, your step-by-step guide for saving energy and resources through your site's waste management program is provided below.

Energy conservation in waste management has four major components:

- reducing the amount of waste produced.
- improving the energy efficiency of waste handling procedures and equipment.
- recovering and recycling waste materials.
- converting waste materials into useful products or energy.

Measures in this section are organized into these four areas.

The process for this section is a simple one consisting of only three steps:

Step 1 - Familiarize yourself with the material in the preceding pages on Waste Management.

If you have not already read this material you should do so before you begin your work on the "Planning Process." It will give you an overview of waste management from an energy perspective; it will explain the organization of the measures for this section; it will define some terms; and it should give you some new ideas.

Table 3 *Advantages and Disadvantages of Hydrolysis and Fermentation of Cellulosic Wastes*
(Source: Reference (11))

Process	*Advantages*	*Disadvantages*
Enzyme Hydrolysis and Fermentation	*1. Up to 90% conversion of cellulose* *2. Glucose easy to store* *3. Careful operation not needed* *4. Not an energy intensive process* *5. Ethanol has a possible use as a fuel* *6. Alternate route to chemicals now made from fossil fuels, therefore conserving resources* *7. Complete utilization of wastes, lignin in sludge has possible use as fuel* *8. Yields of scale-up predictably reliable* *9. Products can be cheaply produced*	*1. Initial pretreatment of refuse still to be optimized* *2. Large scale demonstration still required* *3. Limit to possible markets for products(?)*
Acid Hydrolysis and Fermentation	*1. Glucose is easy to store* *2. Ethanol has possible use as a fuel* *3. Alternate route to chemicals now made from fossil fuels* *4. Costs of sugar and ethanol highly competitive*	*1. Corrosion resistant equipment needed* *2. Careful regulation of temperature and pH required* *3. Only 50% conversion* *4. Treatment of sludge* *5. Energy requirements* *6. Large scale demonstration still to be proven* *7. Limit to possible markets for products(?)*

Step 2 - Work through the measures designated "I" contained on Worksheets I, Potential Conservation Measures.

All refuges and hatcheries can reduce the amount of waste materials that they produce. In general, the measures which lead to a reduction in waste are not costly since they usually involve changing attitudes, habits, and behavior rather than buying and installing new equipment. New policies, combined with training or incentive programs, may be required to effect these changes, however, since these habits may be deeply ingrained.

To make it easier for each refuge or hatchery to consider waste-reducing opportunities, several measures have been designated "I" for "immediate priority." Work through these measures first. In addition, the planning process can be streamlined for this group of measures, and 4 of the 10 columns on Worksheets II, Measures Evaluation may be omitted. These columns are:

- potential benefits
- first check point
- savings
- payback period.

It will be difficult if not impossible for you to calculate savings and payback period for these measures. In some instances you will see tangible results - reducing office paper waste and reusing paper may reduce need for collection and reduce expenditures on paper supplies. These results would be difficult to predict accurately, however, and some actions will produce even less measurable outcomes.

You should think of how the broad measure could apply to your refuge or hatchery, and write specific actions your site could take. These specific activities then become the actual measures that you work through on the measures evaluation. For example, under the first guideline, "reduce the quantity of products and materials used," you could plan to reduce the number of copies of memos to staff by posting a single copy on a convenient bulletin board. Under the second item, "get the most possible value from materials used," you could plan to reuse the back of office paper for notes or draft typing. Using cloth instead of paper towels in kitchens or restrooms is an example of the third item, "buy reusable, durable products instead of disposables." And, finally, cleaning products, foods, and office supplies are examples of products that can be bought in bulk.

In the area of reducing waste, you should not dismiss any measure as too small or insignificant, because changing attitudes and habits will have a snowball effect. In addition to modifying one habit, people will become more aware of wasteful practices and will make other changes on their own, both in the way they perform their jobs and in their private lives. Thus, this section is very important to energy conservation, particularly the incentive ideas which you develop.

Step 3 - Select additional measures and complete Worksheets II, Measures Evaluation.

For the remaining measures on the list marked "H" for "high priority" and "F" for requiring "further study," you should determine whether or not they apply to your site. Then choose those measures which you feel will be cost effective and produce the greatest energy savings.

Use of the measures evaluation for the waste management section is similar to other such sections in the Planning Guide. One area which you may find troublesome, though, is recycling. In this area, your refuge probably will not realize a dollar or energy savings - in fact, it is more likely that such programs will actually cost money and use more energy. The benefits from these programs accrue to the community as a whole in terms of energy conservation rather than to your site. Thus, a decision must be made as to whether the site will spend money on a program that will not directly return energy or dollar savings. Perhaps, like interpretive programs, the rationale for implementing a recycling program might be public education rather than direct energy or dollar savings. By setting an example for the public and getting them involved in such a program, you may encourage them to change their behavior at home.

If you decide to consider any of the measures for converting waste into useful products or energy, you should refer to corresponding sections in On-Site Generation, Volume II.

A sample completed measures evaluation is included following the list of potential conservation measures.

After you have compiled a list of potential conservation measures from Worksheets I for this section and have completed your Worksheets II, you should review the material in the Introduction which explains how to pull all of your measures together into a comprehensive Energy Conservation Management Plan.

REMEMBER: The measures you are considering for waste management are meant to be part of your total plan.

WORKSHEET I
POTENTIAL
WASTE MANAGEMENT CONSERVATION
MEASURES

WASTE MANAGEMENT

Measures	Current Status	Technical Reference**
1. REDUCE WASTE		
1.1 Reduce the quantity of products and materials used where they are not essential to the quality of work performed or services to be provided. I*		
1.2 Get the most possible value from materials used. I		
1.3 Buy reusable, durable products instead of disposables. H		Decision-Makers, pp. 118-120
1.4 Buy products in bulk to minimize the waste of overpackaged goods. Transfer items to smaller containers on site if necessary. H		
2. IMPROVE THE ENERGY EFFICIENCY OF WASTE HANDLING PROCEDURES AND EQUIPMENT		
2.1 Provide a sufficient number of trash containers throughout the site. H		
2.2 Use enclosed trash containers. H		Decision-Makers, pp. 30-32
2.3 Replace large stationary storage bins and metal drums with bulk containers for mechanized collection or smaller lined containers. H		(same as 2.2)
2.4 Install trash containers and ashtrays in all vehicles - encourage staff to use them. I		
2.5 Use covered trucks to carry waste materials to prevent scattering of trash and the need for additional collection of litter. H		Decision-Makers, pp. 48-52
2.6 Use signs to encourage staff and visitors to flatten cans, boxes, and other containers before discarding to reduce the volume of trash to be collected. I		

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* I indicates immediate priority measures which should be considered first.

** These references are part of a core library of materials which should accompany these energy conservation/management planning materials.

WASTE MANAGEMENT

Measures	Current Status	Technical Reference
2.7 Reduce energy use in transporting waste:		
a) Use more efficient collection vehicles, and maintain these vehicles properly for maximum efficiency (see Transportation Section). H *		
b) Reduce frequency of collection, recognizing health and environmental considerations. I		Decision-Makers, pp. 28-29
c) Locate disposal facilities as near as possible to waste sources. H		
d) Construct transfer facilities for long hauls of trash to permit use of larger, high-payload vehicles. H		Decision-Makers, pp. 70-74
e) Use trash compactors at the source, on trucks, or at transfer stations to reduce the volume of trash to be transported. H		Handbook of Solid, pp. 182-3
f) Organize vehicle routing pattern for maximum efficiency. I		A Guide to Reducing, p. 53
g) Deliver only full or nearly full loads to the disposal or transfer area. I		Trucker's Guide, pp. 6-7
2.8 Use appropriately sized equipment for landfill operations. H		Decision-Makers, pp. 112-115
2.9 Presort material before [illegible] to recover usable materia[illegible]		
2.10 Reduce energy consumed in sewage collection, treatment, and disposal systems (see section on Water Conservation). F *		

* H indicates high priority measures which require significant investment but are certain of economic payoff.

* F indicates which measures require further study to determine their economic feasibility.

WASTE MANAGEMENT

Measures	Current Status	Technical Reference
3. RECOVER AND RECYCLE WASTE MATERIALS		
3.1 Use renewable rather than non-renewable products whenever possible. I		
3.2 Consider source separation and separate collection for renewable materials. H		Decision-Makers, p. 38
3.3 Collect and separate solid wastes in order to:		
a) Recover steel and tin. H		Handbook of Solid, pp. 282-285
b) Recover aluminum. H		Handbook of Solid, p. 288
c) Recover paper products. H		Handbook of Solid, pp. 38-47
d) Recover newspaper. H		Handbook of Solid, pp. 38-47
e) Recover glass. H		Handbook of Solid, pp. 283-291
f) Recover waste oils. H		Decision-Makers, pp. 142-145
g) Recover asphalt. H		
3.4 Install clearly labeled indoor and outdoor containers to collect bottles and/or cans for use by staff and visitors, particularly around refreshment stands, picnic areas, and campgrounds. H		
3.5 Sell drinks in returnable reusable bottles with deposit or in returnable recyclable cans with deposit. I		
3.6 Review concession contracts to encourage recycling practices. I		

WASTE MANAGEMENT

Measures	Current Status	Technical Reference
3.7 Use waste wood chips to cover trails and to surround plants. I		
4. CONVERT WASTE MATERIALS INTO USEFUL PRODUCTS OR ENERGY		
4.1 Install alternative toilet systems. (See section on Water Conservation.) H		
4.2 Begin a compost for organic, nonpathological wastes to produce fertilizer. I		Goodbye, pp. 43-49; Handbook of Solid, pp. 14-51
4.3 Generate energy from wastes on site.		
a) Recover waste heat by installing heat exchangers. F		OSG(Biomass)
b) Combust biological waste to produce direct heat or steam heat. F		OSC(Biomass and Cogeneration)
c) Cogenerate electricity with combustion. F		OSG(Cogeneration)
d) Produce methane from digestion of organic wastes. F		OSG(Biomass)
e) Produce liquid fuels (alcohols, oils) from organic wastes. F		Fuel and Energy, pp. 25-29, 51, 56-59; Energy, Agriculture, pp. 271-288
f) Produce fertilizers as a by-product of other processes. F		Handbook of Solid, pp. 27-32

WATER CONSERVATION

The water used for this purpose is usually high quality and suitable for drinking, and it is contaminated with just a few pints of waste. There are several methods for reducing water use in this area, including leak detection, modification of existing toilets, or replacement of existing systems with toilets that use less or

leaks, and steps can be taken to repair it.

Low-cost products are available today that can cut flush volume 10-40% on an existing system. The volume of water used per flush can be reduced by installing inserts or toilet dams in the tank. To allow a choice between light and heavy flushes, a dual flush

Worksheet II: Measures Evaluation

Measures	Potential Benefits	Action Required for Implementation	Barriers to Implementation	First Decision Point
2.1 Provide a sufficient number of trash containers - install an additional 10 lined containers	• Reduce litter • Simplify collection due to less scattering of trash	• Purchase containers	• Trash containers are not attractive and visitors may object to their presence in scenic areas	Go on
2.7.b. Reduce frequency of collection from twice/week to once/week in administrative (non-restaurant) areas	• Savings on fuel for collection vehicles • Savings on staff time	• Policy change • Study volume of trash	• Potential odors and pests if food is involved	Go on
3.3.b. Recover and recycle aluminum	• Energy savings overall - not to park • Set a good example for visitors - get them in the habit of recycling	• Policy • Contact agency that purchases aluminum	• Cost to park for collection and transportation	Go on

Worksheet II: Measures Evaluation (Part II)

Cost	Savings ($ and BTUs)	Payback Period	Training Needs	Motivation Problems and Incentives
• $25-75, depending on type of container - $250-$750	• Staff time in collecting litter - estimate $300-500/yr.	.5-2.5 yrs.	None	None
• Minimal - record volume and type of trash (will present containers be adequate?)				
• Containers for separate collection • Truck for weekly collection • Truck for transportation out of park	• Minimal - price for aluminum is very low		None	• Signs to inform visitors of program and encourage them to participate

WASTE MANAGEMENT

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WASTE MANAGEMENT

ABSTRACTS

Core Sources

Energy, Agriculture and Waste Management, William J. Jewell (ed.), Ann Arbor, Michigan: Ann Arbor Science Publishers Inc., C. 1975. 540 pp.

These proceedings of the 1975 Cornell Agricultural Waste Management Conference cover the following subjects: 1) Energy consumed in food production, 2) Technology and Energy costs of pollution control, and 3) Potential for producing energy from agricultural wastes. Of particular interest are the articles on anaerobic digestion and biomass, although other methods of energy reclmation are investigated as well. Many of the articles are highly technical and address very specific problems.

Decision-Makers Guide in Solid Waste Management, Washington, D.C.: Office of Solid Waste Management Programs, U.S. Environmental Protection Agency, 1976. (Available from U.S. Government Printing Office, #SW-500).

This guide presents the key issues of solid waste management in a decision-making context, attempting to anticipate all the important decisions that must be made in the effort to develop and operate solid waste programs in a responsive, cost-effective manner. Criteria for decision-making include costs, environmental factors, resource conservation, and institutional factors. Each chapter presents an issue, describes the alternatives, gives the advantages and disadvantages, and concludes with a summary statement. The issues covered include: collection; transfer stations and hauling to disposal sites; resource recovery from mixed wastes; sanitary landfilling; reducing waste generation; and special waste.

Handbook of Solid Waste Disposal: Materials and Energy Recovery, Joseph L. Pavoni, John E. Heer, Jr., and D. Joseph Hagerty, New York: Von Nostrand Reinhold Company, C. 1975. 549 pp.

The text presents an in depth description and critique of a wide variety of solid waste disposal and resource recovery processes currently available. The major processes include: composting, incineration, sanitary landfills, innovative disposal processes, materials and energy recovery processes, and European practices. Procedures for the selection of short-term and long-term solid waste management techniques are offered.

WASTE MANAGEMENT

Fuel and Energy Production by Bioconversion of Waste Materials State-of-the-Art, Sylvia A. Ware, Silver Spring, Maryland: Ebon Research Systems, NTIS #PB-258 499, 1976.

This report is a state-of-the-art summary of biological processes for converting waste cellulosic materials agricultural, municipal and lumbering wastes) to fuels. It indicates the locations and quantities of suitable wastes and discusses the status of the current processing schemes. The processes covered are: 1) acid hydrolysis followed by fermentation; 2) enzyme hydrolysis followed by fermentation; 3) anaerobic digestion of manure and municipal solid waste; and 4) biophotolysis. Cost data for these systems are given and where possible compared.

The report concluded that energy production by these methods on a national scale can, at best, produce the equivalent of only about 3 million barrels of oil per day by 1980. These may be economical and environmentally acceptable means of waste management and need further study.

WASTE MANAGEMENT

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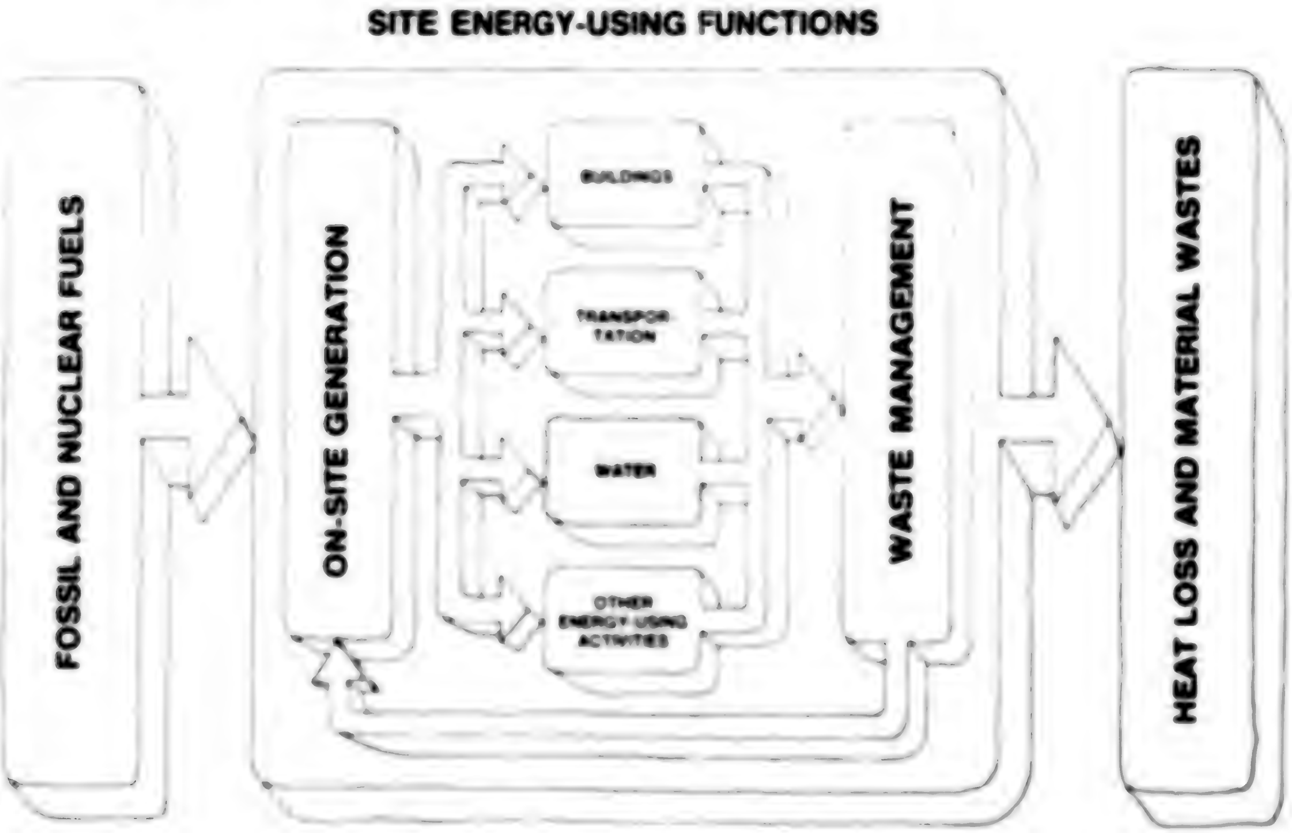
Water Conservation

VOLUME I
BOOK 5



This section on Water Conservation is part of a two volume Planning Guide designed to help you formulate on overall site-specific Energy Conservation Management Plan. It provides you with background information concerning water usage as well as instructions for choosing and developing measures to reduce consumption and improve the energy efficiency of existing water systems.

WATER CONSERVATION

WATER AS AN ELEMENT OF THE SITE SYSTEM

Water use is fast becoming a critical issue to the nation. Larger demands on water sources are causing shortages, while legal and political battles over water rights are on the increase. Due to pollution, the quality of ground and surface water has gone down. Thus more energy is necessary to treat water sources to eliminate health hazards. Water conservation can provide one means for easing these problems.

Energy is required to provide water for consumption and to remove and treat it when it becomes a waste product. As with other energy-using systems, those used to provide water also waste energy. Figure 1 shows a pump used to push water through the pipes to the place where it will be consumed. Although the pump may be 80% efficient, there is still some energy lost in the process. The amount of energy used to process water depends to a large degree on two things -- the volume of water processed and the efficiency of the equipment used at each stage of the process.

Energy is used to provide a number of desired functions in water systems. Water must be taken from its source at the watershed, pumped, purified, and/or heated before consumption. Some of the water used at a site will need to be collected after use, and treated and disposed of through special methods before being returned to the watershed. After treatment, some water may be recycled for primary or secondary uses. Providing each of these functions involves energy waste.

Just as we have come to assume that energy will always be available, we have also grown to take it for granted that there will always be enough water available to meet our everyday needs. We use water for many things, including:

- personal hygiene
- cleaning
- cooling or heating
- drinking and cooking
- irrigation and landscaping
- decoration and recreation
- aquaculture and other process uses
- waste separation and transport.

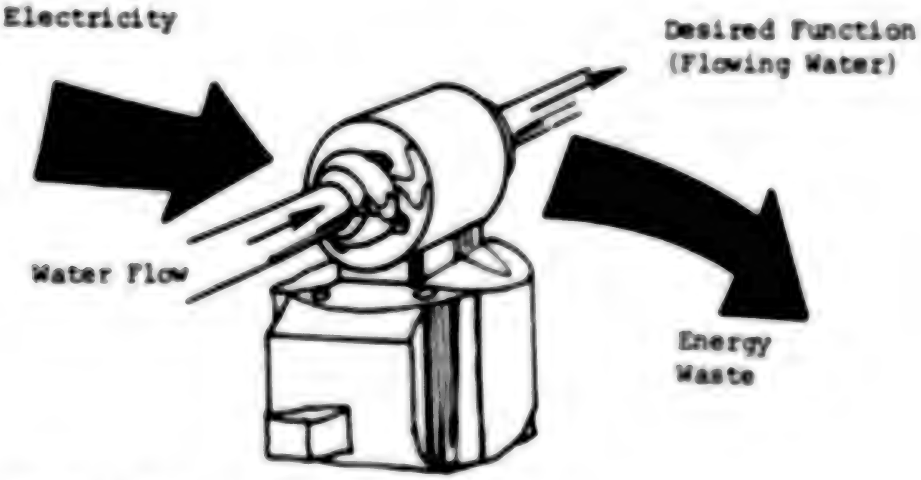


Figure 1 *Energy Flow*

WATER CONSERVATION

The water systems we use today may entail extravagant and unnecessary demands for supply, purification, collection, treatment, and disposal of fresh or reclaimed water. Although it's unfortunate that existing systems are wasteful of two basic resources, it is also true that conservation opportunities in this area are doubly significant: in many cases, actions taken to conserve water will also yield energy savings.

CONSERVATION MEASURES

To reduce waste of both water and energy, two broad strategies are outlined below:

1) Reduce water and energy consumption, and

2) Improve the energy efficiency of existing water systems.

The first strategy involves limiting the amount of water or energy demanded through reducing flow. The second involves upgrading the performance of existing equipment and processes, such as pumps, heaters, and waste treatment facilities. The actual amount of energy required to perform a task can be found by physical measurement and data collection. This can then be compared to a theoretical or ideal amount of energy use for performing the same task, to identify potential for improvement. The two strategies are highly complementary and overlap at points. For example, one method for improving the efficiency of the pumping system at a fish hatchery may be to reduce the demand for water, thereby allowing installation of a smaller pump or one with variable speeds.

In implementing both strategies, it is important to consider reducing or eliminating unnecessary process stages. For example, reducing the number of pumps used to move water can yield considerable energy savings over time.

Reduce Water and Energy Consumption

The first conservation strategy is to reduce overall demand for water and energy by seeking to change both the pattern of usage and the appliances, showerheads, toilets, and other pieces of equipment which consume water for different functions. For each area described below, there is an indication of its relative importance to total water and water-related energy use, and a discussion of important conservation opportunities.

General

Because using large amounts of water has become second nature to most people, it is necessary to draw their attention to the need for conservation practices. Measures included in this category are general, in that they encourage shifts in attitude and behavior that will apply to many situations.

Toilets

The flush toilet is a leading water user, consuming 5-7 gallons per flush. On the average, a person flushes five times per day. Forty percent of residential water use is for toilet flushing, and in commercial and public facilities, the percentage of total water use for flushing is considerably higher, approaching 90%.

WATER CONSERVATION

The water used for this purpose is usually high quality and suitable for drinking, and it is contaminated with just a few pints of waste. There are several methods for reducing water use in this area, including leak detection, modification of existing toilets, or replacement of existing systems with toilets that use less or no water.

Toilet leaks can waste thousands of gallons in a year's time. These can be detected by adding a few drops of food coloring to the tank, and watching to see if color shows up in the bowl. If this occurs, the tank leaks, and steps can be taken to repair it.

Low-cost products are available today that can cut flush volume 10-40% on an existing system. The volume of water used per flush can be reduced by installing inserts or toilet dams in the tank. To allow a choice between light and heavy flushes, a dual flush unit can be attached.

When purchasing new equipment, one should consider alternatives to the conventional toilet that will result in lower total energy and water costs. In Table 1, several alternative toilets are described. Some use

Table 1 *Water Use in Toilets (1)*

Type	*Design Features*	*Maintenance Problems*	*Water Use*	*Direct Energy Use*
Conventional toilet	*2 pieces -- toilet & tank*	*leaks*	*5-7 gallons per flush; suitable for greywater recycle*	*none*
Shallow trap toilet	*smaller tank & shallower trap than conventional*	*clogging due to smaller passageway*	*3-3.5 gal. per flush; suitable for greywater recycle*	*none*
Pressurized flush toilet	*wastes evacuated by gravity & air pressure propulsion*	*similar (or less) upkeep than conventional*	*2 quarts per flush*	*electricity*
Composter toilet	*aerobic decomposition of kitchen & toilet wastes; end product is a soil conditioner; air flow removes excess water as vapor*	*occasional maintenance & removal of humus*	*no water used*	*little or no electricity; can be solar powered*

electricity, but do not use water. This can lead to a savings in energy for pumping, collection, treatment, and disposal of the water used in conventional systems. The savings may more than offset the energy used directly in these systems.

Baths and Showers

Approximately 30% of all the water used in a household is for bathing and showering. More important from an energy perspective, between 50 and 75% of hot water use in the home is for this purpose. Substantial energy and water savings can be realized by reducing flow and lowering hot water temperatures. There are three principal approaches for accomplishing this -- changing habits, refitting existing systems, and making wise choices in the selection of new equipment.

Due to the availability of cheap and abundant supplies of both water and energy in the past, people have become accustomed to using large amounts of hot water for bathing and showering. With attitude and behavior changes, water and energy can be saved by showering for shorter time periods and by using a lighter water flow. Using lower temperature water helps to reduce energy demands for hot water heating.

Refitting existing systems also offers real opportunities for savings. A conventional shower head delivers five to six gallons per minute (gpm) at full flow.(2) This can be reduced by using flow restrictors, lower flow shower heads, or aerating heads. The flow rate on these units can range from a low of 1.3 gpm for an aerating head to as much as 4.3 gpm for a flow restricting head.(3) The costs for these units should be carefully compared against potential savings in energy and water before deciding on which model to install. Similar devices can also be used with faucets and can yield substantial savings. Also, hot water heaters may be adjusted so that hot water is supplied at a lower temperature.

When purchasing new equipment, tubs may be specified that will minimize the amount of water used for bathing, and flow restrictors or aerating devices can be installed in shower fixtures.

Laundry

Under normal circumstances, the laundry accounts for only about one-seventh of total residential water usage. As savings are obtained by modifying toilets and showers, the laundry's percentage of total use will increase. Automatic washers are the principal energy-using systems in the laundry, consuming about 100 kWh of electricity per year, on the average.(4) Indirectly, washers also require large amounts of energy to heat the (hot) water used in washing. Between 1.5 and 3 gallons of water are required for each pound of clothes washed in an automatic machine.(5) To realize savings in this area, the first step is to reduce hot water usage. If the machine has a water volume control, the appropriate amount of water should be chosen to correspond with the weight of the laundry.

Kitchen and Cafeteria

About 10% of total residential water use occurs in the kitchen. Although there is no single measure that will result in large energy and water savings in the kitchen, a little saved in many places will add up. In cafeterias and food service operations, substantial savings may be possible in this area. Energy may be

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WATER CONSERVATION

Measures	Current Status	Technical References**
1. REDUCE ENERGY AND WATER CONSUMPTION		
1.1 General		

conserved by reexamining routine practices and habits. For example, a common function performed in most kitchens is dishwashing. This can be done by hand or with a dishwasher, and the difference can have a considerable impact on energy use. Washing by hand requires less energy, and water can be conserved by using two basins -- one for washing and one for rinsing. Hot water does not have to be kept running from the tap to get dishes clean and sanitary.

If the dishwasher is used, it's more economical to wash a full load. The drying cycle may be reduced by adjusting the power dryer so only a small amount of heated air is delivered. Regular maintenance, such as inspecting for leaks and cleaning spray nozzles, will improve the energy efficiency of the unit. In purchasing new equipment, low temperature dishwashing systems that use water heated to 110° F rather than 165° F or more are worthy of consideration.

Landscaping, Irrigation, and Other Outdoor Uses

Energy and water can be conserved in landscaping and irrigation by reducing the volume of water required and by improving the energy efficiency of existing systems and operations. There are many opportunities in volume reduction. First, drip irrigation may be used for crops or gardens. This system delivers water to plants drop by drop through pastic pipes. Used correctly, it provides plants with the exact amount of water they require without waste due to runoff and evaporation. Second, monitoring soil moisture of lawns or gardens will indicate the appropriate time for watering. Third, proper application of mulching in conjunction with scheduled irrigation can reduce water runoff and evaporation. Fourth, in areas where irrigation will be needed, plant species requiring little water or drought-resistant plants can be chosen. Green areas in arid climates that are maintained at high energy and water costs may be returned to their natural state.

Direct and indirect energy use in this area can also be reduced by changing to lower quality water sources and by improving the operating efficiencies of equipment and systems. Instead of using drinking quality water for irrigation and landscaping, using rain water or greywater (see definition under section #2, "Collection, Treatment and Disposal") can yield dramatic energy savings. Wherever possible, pumps should be replaced with gravity flow systems. When methods for reducing water demand have been examined, the operating efficiency of pumps, sprinkler systems, and other equipment should be tested and improved where necessary. Regular maintenance and repair can yield considerable savings over time.

Fish Hatcheries

Fish hatcheries present a special set of problems in dealing with water-related energy conservation. They use large amounts of water and are often specially designed for a particular location and set of conditions. Opportunities for energy and water savings, however, are often much larger for hatcheries than for comparable sites of the same size which do not use water for process use.

In assessing conservation measures, hatchery personnel must have a thorough understanding of actual demand for water and energy to perform needed tasks. For instance, it may be possible to reduce the volume of water pumped into raceways, but the amount of reduction possible will depend on how much is actually required for each

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WATER CONSERVATION

Measures	Current Status	Technical References
e) Consider installing urinals to reduce flush quantity to 1.5 gallons. F *		*Residential*, pp. 174-178

fish species. Equipment, such as pumps and water heaters, may have been designed to meet a high level of demand and may be operating at very low efficiencies under present conditions. In such cases, expensive measures involving redesign and installation of new equipment may be cost-effective, given rising energy costs.

There are many methods for reducing the energy used for pumping at hatcheries. Pumps that operate at a single speed only may waste considerable amounts of electricity, when actual demand is for a fraction of the service provided. Installation of pumps with variable speeds can help to eliminate this problem. When hatcheries are planned or redesigned, every effort should be made in the design stages to use gravity flow instead of pumping. Diverting river or stream water by the use of conduits can offer large energy savings over the life of the facility. Although it may be more expensive at the outset, the reduction in life cycle costs can pay for the installation.

Pumping water is also one of the best applications of both small-scale hydroelectric, wind mechanical and electric energy systems. Hydraulic rams run at virtually no energy cost and perform the added function of aerating pumped water. On-site energy sources should be explored wherever there are high energy demands for pumping and required environmental conditions appear favorable (see Volume II, On-Site Generation).

Energy used for treatment can also be reduced by using raw water from the source, provided that adequate monitoring of water quality is performed.

Because the volumes of water which must be heated are so great at some hatcheries, there are strong reasons to investigate alternative methods of heating, especially those using on-site energy sources. In particular, solar thermal equipment can be appropriate and highly cost-effective in many locations. Small-scale hydroelectric equipment may also be a possibility, especially when heating and pumping needs are combined. These equipment types should be investigated thoroughly for feasibility (see Volume II, On-Site Generation).

Energy used in pumping and treating waste water can be cut by several methods. First, wastes may be appropriate for other uses, such as irrigation. Treatment then becomes unnecessary and the energy costs of that stage are fully avoided. Second, the efficiencies of existing equipment can be improved. Finally, on-site energy sources can be used to displace the conventional fuels in use at the present time.

Cooling Systems

Energy is used for cooling in many ways. A more complete discussion of how to improve the energy efficiency of such systems is presented in the Buildings section. Water use for cooling can involve substantial energy costs and can be reduced in several ways. Timing devices and controls can be used to limit water use to the time of actual need. Recycled water can be used for certain cooling processes, reducing demand for source water. Inefficient cooling equipment may be replaced with more efficient units. For example, an old, oversized refrigeration system may be replaced with a modern, properly sized system to save considerable energy used for water cooling.

Hot Water Systems

Hot water systems in buildings are often tied into the furnaces,

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WATER CONSERVATION

Measures	Current Status	Technical References
1.5 Kitchen (Cafeterias)		

boilers, and other equipment used for space heating. For this reason, measures to improve the energy efficiency of hot water systems have been included and discussed in the section on Buildings. Because energy savings in this area are an important component of overall potential for water-related energy conservation, however, those measures are also listed in this section.

The per unit energy costs of heating water are higher than the per unit costs to perform any other desired function with water. Energy used for heating domestic and basic service water is greater than for any other function in buildings except space heating and cooling. These systems often waste energy, and the potential conservation opportunities are great.

Savings may be obtained by reducing demand for hot water, reducing the average temperature, and improving the overall efficiency of the hot water heating and distribution system. In evaluating measures in this area, it is important to understand how demand can be modified, since saving a small amount of hot water will be equivalent to reducing demand for a large amount of unheated water.

Improve Efficiency of Existing Systems

The first strategy for energy and water savings -- reducing consumption -- should be complemented by the second -- improving efficiency of existing systems. Measures should be taken which will improve efficiency at each process stage.

Water Source

The primary energy use at this stage is for pumping. Pumps maintain a certain rate of flow at a set pressure in pounds per square inch (PSI). Both the flow rate and the PSI can be adjusted downwards to save energy. Maintaining accurate records on hot and cold water supplied to the site will help in making such adjustments and in monitoring demand over time. Regular maintenance can help assure that pumps are operating efficiently and that supply lines are in good condition.

Purification

There are two principal methods for reducing the amount of energy used for purification. The first of these is to use water of lower quality wherever possible. When less pure water is used, less energy is necessary to perform the desired functions of treatment and purification. This will be discussed further, under Collection, Treatment, and Disposal, below. The second method is to improve the efficiency of purification systems and processes, such as filtration units.

Collection, Treatment, and Disposal

There are substantial opportunities for saving large amounts of energy and water at the stage of final collection, treatment, and disposal, since the processes used to accomplish these functions are often energy and water intensive. Conservation efforts at this stage may sometimes bring site managers into conflict with other government agencies. For an increased concern for high water quality levels has led the Public Health Service, the Environmental Protection Agency and state and local regulatory agencies to set high standards which require that contaminants be reduced to very low levels. This can involve substantial energy and water costs. By examining

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WATER CONSERVATION

Measures	Current Status	Technical References
d) Leave grass at least 2" high to hold		

water and water-related energy usage at the site, opportunities for conservation will emerge that do not necessarily result in reduced quality of effluent discharges. Analyzing these opportunities, however, will almost certainly call for professional expertise and technical assistance, once a tentative strategy has been outlined.

There are two prime approaches to take at this stage: reduce the volume of water treated by more advanced and energy-intensive processes, and improve the energy efficiency of those processes.

In implementing the first approach, you start by identifying different streams of waste water. Greywater is water that has been used for cleaning, cooking, or other purposes, but which has not been contaminated in a toilet. Blackwater is effluent from toilets. In California, where serious water shortages have prompted a recent reassessment of allowable uses for reclaimed greywater and blackwater, the State Water Reclamation Board has determined that reclaimed greywater can be reused without treatment for watering orchards, vineyards, and seed and fiber crops. With filtration and disinfection, it can also be used to irrigate fodder crops and irrigate pasturage for milk cows. Studies have shown that using greywater to fill toilet tanks can yield a 30 to 40% savings in water used for flushing. To implement these options, however, involves a thorough examination of plumbing codes; since some of them do not allow installation of separate plumbing for greywater and blackwater.

A further reduction in demand for water treated by more advanced processes may be achieved by using reclaimed blackwater for certain purposes. This option must be carefully evaluated from the energy perspective, since more advanced treatment processes are required to reclaim fully contaminated water wastes. The California Water Reclamation Board allows the use of reclaimed blackwater for the following purposes:

- irrigation of food crops by spray or surface methods
- irrigation of fodder, fiber, and seed crops
- landscape irrigation for such things as lawns, ornamentals, freeway landscapes, landscape ponds, cemeteries and golf courses.

Where this type of use involves substantial energy costs for pumping from underground aquifers or remote sources of supply, blackwater reclamation may be a reasonable alternative.

In general, the higher the required level of water quality, the more technically sophisticated and energy-intensive is the equipment needed to raise it to that level. There is a kind of ladder of energy intensity for treatment and disposal processes, with cesspools and septic tanks on the low rungs and advanced treatment processes, such as tertiary treatment, ion exchange, and reverse osmosis on the highest rungs. Septic tanks are used in rural areas and in some suburban locations where water percolates easily. They are tanks made of concrete or similar materials that retain solids from the waste water stream and allow water to run off into the surrounding earth. Since the solids are broken up by a process of anaerobic decomposition, no energy is required except what is occasionally needed for cleaning the tanks. In primary treatment, floating solids are removed by screening and heavier solids are removed after settling to the bottom. The sludge is then disposed of by landfill or incineration.

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Measures	Current Status	Technical References
m) Use an instantaneous moisture indicator or other soil moisture		Orchard, p. 16; Residential, pp.

Primary treatment, however, is usually inadequate to meet water quality standards. Phosphates, nitrates, and substantial quantities of oxygen-demanding substances remain in the effluent. In secondary treatment processes, chemical agents are added which cause further precipitation of undesirable chemicals and bacteria. When these settle, they are removed with scrapers and the sludge is disposed of. Chlorine may be added to kill remaining microorganisms. In tertiary treatment, a series of chemical and physical processes reduce contaminants, such as phosphates, nitrates, and other dissolved solids. It involves high energy consumption, chemical consumption, and sludge-handling problems.

A thorough analysis of water quality levels, the demand for advanced treatment, and the volume of water handled at each level can reveal applications for water treated at the lower rungs of the ladder of energy-intensive processes. Since disposal of sludge in landfill operations can also involve energy costs, these should be included as part of the analysis.

The second approach -- improving the efficiency of equipment and systems used for collection, treatment, and disposal -- can be accomplished as part of routine maintenance, for the most part. For technically sophisticated systems, special engineering expertise may be required to determine whether the system is operating at peak efficiency.

PLANNING PROCESS

The planning process to be followed in completing this section is similar to the general planning approach described in the Introduction and should help you in formulating your comprehensive water conservation strategy based on the information just presented.

The overall steps to be followed to complete this section are:

Step 1. Review the material on water conservation in the preceding pages.

This material provides an overview of strategies for reducing water and energy consumption and explains the organization of the measures for water and energy conservation.

Step 2. Collect preliminary data.

Before you can make decisions on how to reduce water and energy consumption, you need to find out how much is used at your refuge or hatchery, and for what purposes.

Step 3. Review Worksheets I, Potential Water Conservation measures designated "I" for "immediate priority."

You will find that a large number of water conservation measures can be implemented by a little consciousness-raising and habit changing. For example, it is really just as easy to collect some hot water in the sink for shaving as it is to let the hot water run. A little positive thinking in cases like this will begin the conservation effort.

You should begin this section by reviewing the measures designated "I" and figuring out how they can be implemented at your refuge or hatchery. Few of them require money; most will require a policy, staff training, or an incentive program. Since savings and payback will be difficult to calculate and the benefits to be

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
c) Install separate pumps for separate tasks, using pumps sized for the		

derived from these measures are obvious, the planning process can be shortened somewhat for this group of measures. When considering them, you may omit 4 of the 10 columns on the planning worksheet:

- potential benefits
- first check point
- savings
- payback period.

As you work through these measures, focus on how you can get people involved in water conservation by raising their awareness and interest. A successful water conservation awareness program may include brochures, posters, stickers, etc. Materials are frequently available from local water commissions or companies. If you succeed in this, your efforts will have much greater impact since people will take new attitudes into their homes as well as their work environment.

Step 4. Assess the value and feasibility of measures involving significant expense or technical changes on the planning worksheets.

Of the remaining measures, where substantial cost is involved, the process calls for an assessment of applicability, feasibility and value. Some of the measures will not even apply to your situation. Some will not be feasible due to extensive modification costs or other incompatibilities. The remaining should be given a benefit/cost analysis so that priorities can be set.

For the measures requiring a major capital outlay, it will generally be best to enlist the aid of an engineering economist. Usually there are other issues involved, such as a need for additional water supply or increased sewage treatment plant capacity and/or performance. When these issues come up it is best to consider all elements together with an in-depth analysis. Your preliminary assessment of these projects on the Worksheets II, Measures Evaluation will determine which are worthy of further study and will provide an outside expert with a valuable foundation for the in-depth assessment.

To help you reach decisions regarding water and energy conservation measures, several Data Forms have been prepared for your use. They include:

Data Form 1: Water Use Reduction, p. 13

Several methods are presented for calculating reduction in water use that can be achieved through implementing conservation measures.

Data Form 2: Equipment Efficiency Form, p. 14

A simple formula is presented and explained that will allow you to calculate the efficiency of certain important pieces of equipment, particularly hot water heaters and pumps.

Data Form 3: Energy Use Reduction, p. 15

Methods are presented for calculating reductions in energy use that can be achieved by reducing water use and/or improving the efficiency of existing equipment and processes.

As you are working through the measures, you may find it helpful to pose the following questions:

- can water flow be reduced or eliminated at the point of use without adverse effects?

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Measures	Current Status	Technical References
1.9 Hot Water Systems		

WATER CONSERVATION

- can the pressure or temperature of the water at the point of use be lowered without adverse effects?
- can the water quality at the points of use be lowered without adverse effects?
- are the wastewater treatment processes used appropriate for each use, or can adjustments be made to improve overall efficiency, quality and energy efficiency without adverse effects?
- can processing equipment efficiency within the facility be improved?

When you consider potential barriers to implementation of the measures, you should be aware of nonfinancial, social and environmental factors as well as those which are related to technical, funding and implementation concerns. These include consideration of:

- safety
- aesthetics
- reliability
- flexibility
- compatibility with existing systems
- operability and ease of maintenance
- primary and secondary environmental effects
- use of renewable resources.

A sample completed planning worksheet is included following the list of potential conservation measures.

After you have compiled a list of potential conservation measures for this section and have completed your planning worksheets, you should review the material in the Introduction which explains how to pull all of your measures together into a comprehensive Energy Conservation Management Plan.

REMEMBER: The measures you are considering for water conservation are meant to be a part of your total plan.

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WATER CONSERVATION

Measures	Current Status	Technical References
i) Relocate water heater as close to the point of use as possible to reduce		

DATA FORMS

It is important to remember that these forms should be used only when they help you to make calculations that assist in the planning process.

Data Form 1, Water Use Reduction, may be used to estimate, on an annual basis, the potential annual water savings from a given measure. Two methods are presented for doing this. Method 1 should be used when you are certain of both the present water use for a given unit - such as the number of gallons used to flush a toilet - and the amount of savings to be obtained from installing a new unit or taking other measures. For example, if you know you'll save 2.5 gallons per flush by installing toilet dams, insert that figure under "Water Savings/Use/Unit" and work the calculation. Method 2 should be used for such items as showerheads, flow restrictors, or other new pieces of equipment or practices that improve efficiency by reducing the rate of flow. To use this method, insert information on flow in the column marked "Gallons/minute." The calculation is then worked out to give total annual usage. Annual usage using the new equipment is then subtracted from the annual usage using the present system, to give annual savings.

Data Form 3, Energy Use Reduction, may be used to calculate the amount of energy saved by changing equipment or practices. To use the form you should have obtained a per unit energy factor by dividing annual water use (A) in a process, by the annual energy consumption (B) for the same process. In Method 1, this is multiplied by the total number of units, such as gallons of water, to give total energy consumption for that process. The calculation can be performed using annual data for any other period of time, such as a day, a month, or a quarter. Use the per unit energy factor for your new piece of equipment or practice and when you have performed the calculation, subtract the figure from the one for your existing equipment or practice to find the energy savings. Use Method 2 when you are estimating the energy savings that will come from reducing water volume. Multiply the amount of water saved by the annual per unit energy factor for that process to give the annual energy savings.

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WATER CONSERVATION

Measures	Current Status	Technical References
a) Install pressure reducing valves on		

Facility: ____________
By: ____________
Date: ____________

DATA FORM I

WATER USE REDUCTION

(gallons)

METHOD 1

MEASURE (1)	Water Savings/ Use/unit (2)		Unit Uses/ Day (3)		No. Units (3)		Days/Yr.		Annual Savings
	____________	x	____________	x	____________	x	____________	=	____________

METHOD 2

	Gallons/minute		Minutes/use		Unit Uses/Day		No. Units		Days/yr.		Annual Usage	
Present Equipment or Practice	____________	x	____________	x	____________	x	____________	x	____________	=	____________	(x)
New Equipment or Practice (2)	____________	x	____________	x	____________	x	____________	x	____________	=	____________	(y)

Annual Savings (x - y) ____________.

DATA FORM 2

EXAMPLE EQUIPMENT EFFICIENCY CALCULATION

To determine the efficiency of particular pieces of equipment, several factors are required:

A. Total volume of water processed in a given period (X).
B. Average work units performed (e.g. °F temperature rise for hot water).
C. Ideal energy use per work unit. This is a theoretical figure for the amount of energy required to perform the work, assuming 100% efficiency. (For water heating, this is 8.31 Btu to raise one gallon of water one °F. For pumping, it is .0247 Btu to raise one gallon of water one PSI.)
D. Total power or energy consumption used for the process, during the given period (X).
E. The conversion factor from units of power or energy (kWhr or gallons of fuel) to Btu.

The formula used is:

$$\% \text{ Efficiency} = \left(\frac{A \times B \times C}{D \times E}\right) \times 100$$

Conversion Factors are:

3,413	Btu/kWhr Electricity
103,000	Btu/100 Ft^3 Natural Gas
91,500	Btu/Gallon Propane
139,600	Btu/Gallon #2 Fuel Oil
152,400	Btu/Gallon #6 Fuel Oil

Example One:

A pump operates at an average flow rate of 10 gallons per minute, 365 days per year. PSI is 20, and 2535 kWhr are used for pumping. What is the efficiency?

A. Total volume = 10 GPM x 60 minutes x 24 hours x 365 days = 5,256,000 gallons/yr.
B. PSI = 20
C. .0247 = ideal energy use for one PSI.
D. 2,535= kWhr/year
E. 3,413= Btu/kWhr

$$\frac{A \times B \times C}{D \times E} = \frac{5{,}256{,}000 \times 20 \times .0247}{2{,}535 \times 3{,}413} = \frac{2{,}596{,}464}{8{,}651{,}955} = 30\%$$

Example Two:

An electric hot water heater, operating 365 days per year, raises water 100°F. Each day 100 gallons are heated. In a year's time, the process has consumed 14,812 kWhr. What is the efficiency?

A. Total volume = 100 gallons x 365 = 36,500
B. °F = 100
C. 8.31 = ideal energy use for one °F rise.
D. 14,812= kWhr/year
E. 3,413= Btu/kWhr

$$\frac{A \times B \times C}{D \times E} = \frac{36{,}500 \times 100 \times 8.31}{14{,}812 \times 3{,}413} = \frac{30{,}331{,}500}{50{,}553{,}356} = .5999, \text{ or } 60\%$$

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
8) Consider alternative soil absorption location.		

Facility: ______
By: ______
Date: ______

DATA FORM 3

ENERGY USE REDUCTION

METHOD 1

Existing Equipment or Practice	(Annual) per unit energy factor		Total (annual) units		(Annual) energy consumption
	______	x	______	=	______ (x)

New Equipment or Practice (2)					
	______	x	______	=	______ (y)

(Annual) energy savings (x-y) ______

METHOD 2

Process	Water Volume Reduction (Savings)		Annual per unit energy factor		Annual Energy Savings
______	______	x	______	=	______

WORKSHEET I
POTENTIAL WATER CONSERVATION MEASURES

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WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References**
1. REDUCE ENERGY AND WATER CONSUMPTION		
1.1 General		
a) Fix all water leaks immediately. I *		
b) Never put chemicals, paints, grease, fats or oil down the drain. I		
c) Turn water on only when needed. I		
d) Avoid the use of filtering and softening units for purification of home drinking water. I		Residential, pp. 304-7
e) Encourage staff and visitors to use conserving practices. I		
f) Install self-closing faucets wherever practical. I		
1.2 Toilets		
a) Flush only urine, feces, and toilet paper down the toilet. I		
b) Locate and repair toilet leaks immediately. By adding a few drops of food coloring to the tank, you can easily locate small leaks that would otherwise be invisible. I		
c) Reduce the toilet flush volume by adding a plastic water-filled bottle or installing other devices in the toilet tanks to minimize the flush or leaks, such as dual flush devices, variable flush devices, leak signaling ballcocks, or toilet dams. I		Residential, pp. 220-232
d) Replace existing toilet tanks with 2-3 gallon flush tanks. H *		

** These references are part of a core library which should accompany these energy conservation/management planning materials.

* I indicates Immediate Priority measures which should be considered first.

* H indicates High Priority measures which require significant investment but are certain of economic payoff.

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
e) Consider installing urinals to reduce flush quantity to 1.5 gallons. F *		Residential, pp. 174-178
f) Consider installing automatic flush "trough" type urinals in high use areas. F		Residential, p. 176
g) In renovations and new building construction, install shallow trap or composting toilets. H		Residential, pp. 179-181, 185-187, 201-205; Goodbye, pp. 36-41, 51-160
1.3 Bath and Shower		
a) Install flow reducing shower heads and faucet aerators. I		Residential, pp. 239-243
b) Consider installing "air assisted" shower systems. H		Residential, pp. 255-257
c) Install a pressure/temperature mixing valve at each shower/tub. H		Residential, pp. 248-252
d) Change sink faucets to use foot controls that are automatic self-closing. H		Residential, p. 245
e) Change sinks and tubs to the minimum volume type. H		Residential, pp. 260-262
1.4 Laundry		
a) Install a "suds saver" to reduce amount of warm water used. I		
b) Replace existing washers with a water saving model that includes a suds saver. H		Residential, pp. 281-285
c) Use cold water for washing, whenever possible. I		

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* F indicates measures which require further study to determine their economic feasibility.

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
1.5 Kitchen (Cafeterias)		
a) Install sink flow reducing aerators. I		
b) Reduce the hot water supply temperature to the minimum acceptable. I		
c) Consider food cleaning utensils (such as peelers) and cooking utensils (such as waterless cookers) that use less water. I		
d) Consider new refrigerators with cold drinking water dispensers. F		Residential, pp. 270-271
e) Consider knee or foot controls to operate kitchen faucets. H		Residential, p. 245
f) Consider installing a dishwasher since it generally uses less water (for cafeteria units, make sure maximum re-use is made of all hot and soapy water). H		Residential, pp. 279-280
g) Consider installing instant hot water taps for hot beverages to avoid hot water standby losses. H		Residential, pp. 274-275
h) Evaluate energy use of existing drinking water coolers. I		Residential, pp. 272-273
1.6 Landscaping, Irrigation, and Other Outdoor Uses		
a) Wash equipment and vehicles out of a bucket, using a hose for the final rinse only, and washing them less frequently. I		
b) Don't use water to "wash down" the sidewalk or driveway; use a broom. I		
c) Use heavy mulch coverings to prevent soil drying. I		

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
d) Leave grass at least 2" high to hold more dew and to shade the root system. Some clover seeds help to keep the lawn green. I		
e) Select plants that need little or no extra water. Study the wild vegetation in the area to get an indication of what is best. Water in the early morning -- try a ground soaking hose instead of sprinkling, if possible, to minimize losses by wind and direct evaporation. I		
f) Make sure the lawn sprinkler is properly aimed. I		
g) Use pistol grip nozzles (spring shut off) on all hoses to avoid waste and always turn off the main faucet when through to prevent waste. I		
h) Make major landscape changes and new planting just before the rainy season. I		
i) Recycle or turn off any decorative water displays or fountains. I		
j) Consider a rain water catchment and storage system for plant watering. H		
k) Consider recycling gray water for plant watering. H		Goodbye, pp. 190-191
l) Consider an electronically controlled automatic sprinkler system or drip irrigation system. F		Residential, pp. 333-339 Orchard, p. 12

Measures	Current Status	Technical References
m) Use an instantaneous moisture indicator or other soil moisture measuring technique to control watering amounts. F		Orchard, p. 16; Residential, pp. 328-332
n) Relandscape using materials that don't require water. H		
o) Rework topography of landscaped planted areas to prevent runoff. H		
p) Replace open header ditches in sandy soils with plastic pipe. F		Orchard, p. 15
q) Operate irrigation equipment at maximum efficiency. I		Orchard, p. 13, 17
r) Shut off or provide spring operated faucets on all outdoor drinking fountains. I		
s) Refrain from heating outdoor pools. I		
t) Cover outdoor pools when not in use to minimize evaporation. I		Residential, pp. 342-344
u) Eliminate unnecessary waterings. (For example, let unnaturally "green" areas return to natural state.) I		
1.7 Fish Hatcheries		
a) Wherever possible, use gravity flow to avoid pumping. I		
b) Design new raceways to use minimum amount of water for the species of fish to be raised. H		

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
c) Install separate pumps for separate tasks, using pumps sized for the specific task so that operation will be at optimum efficiency. H		
d) Use renewable energy (such as solar, wind, or hydropower) for pumping. (See On-Site Generation, Vol. II). F		
e) Use renewable energy to heat raceway water to optimum spawning and rearing temperatures. (See On-Site Generation, Vol. III) F		
f) Match the quality of water to its intended use, thereby reducing purification costs. (For example, consider using raw river water in raceways, purifying only when absolutely necessary.) F		
g) Use waste water for irrigation. F		Treatment, pp. 68, 70
h) Minimize use of water treatment processes requiring energy, including heating, chilling, ultraviolet treatment, reuse and aeration. F		
1.8 Cooling Systems		
a) Roof "spray" cooling, if cost-effective, should be set to minimize "drain off" and recycling should be considered. F		ECM-2, p. 150
b) Control roof "spray" cooling systems to come "on" only during periods of need and then only long enough to fully wet the roof surface. F		
c) Replace "once through" water cooled air conditioners if total energy consumption is excessive with more efficient systems. (See Buildings section.) F		Residential, pp. 311-313

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
1.9 Hot Water Systems		
a) Make sure that hot and cold water piping to hot water tanks is properly installed and maintained.	I	
b) Consider installing point of use water heaters to minimize standby losses.	F	
c) Consider eliminating hot water supply for certain tasks (for example, outdoor showers).	F	
d) Consider alternative renewable fuels or waste heat to heat water and improve energy use efficiency. (See On-Site Generation, Vol. III)	F	
e) Improve water heater efficiency. (See Buildings section.)	I	
The following measures have been duplicated from the Buildings section of the Planning Guide as they pertain to energy conservation in water systems:		
f) Maintain systems properly:		
1) Test hot water controls to determine if they are working properly. (T)*	F	
2) Regulate, repair, or replace defective controls. (T)	F	
3) Inspect and repair insulation on tanks and pipes regularly.	I	
g) Insulate hot water storage tanks.	I	ECM-2, p. 116
h) Insulate hot water pipes.	I	ECM-2, pp. 115-116

(T): Technical assistance from an engineer or an engineering economist is suggested.

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
i) Relocate water heater as close to the point of use as possible to reduce quantity of water stored in pipes. (T) F		
j) If hot water is distributed through forced circulation, turn off pump when building is unoccupied. (T) F		
k) Limit duty cycle on electric water heaters to avoid adding to periods of peak electrical demand. (T) F		
l) If cooking facilities are used only on occasion, deactivate hot water system when not in use. I		
m) Reduce hot water temperature to 90°-100°F. Use higher temperatures locally for kitchens, and other areas where it is needed. (T) F		ECM-2, p. 117
n) Use waste heat from other processes to preheat hot water. (T) F		ECM-2, p. 123
o) Install separate boiler for summer generation of hot water. (T) F		ECM-2, p. 117
p) Replace central system with local heating units such as hot gas exchangers, hot drain exchangers, and hot condensate heat exchangers. (T) F		ECM-2, pp. 117-120
2. IMPROVE EFFICIENCY OF EXISTING SYSTEMS		
2.1 Water Source		
a) Meter and record hot and cold water use at facilities to determine minimum quality for use. I		
b) Revise accounting procedures to eliminate any discount for increased use of water. I		

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
c) Install pressure reducing valves on facility water supply to lower pressure to 40-50 PSI to reduce flow (make sure that fire protection requirements are met and upper floor pressure is adequate). H		
d) Reduce delivery pressure so that facility pressure is 40-50 PSI max., if possible. F		
e) Minimize supply losses by inspecting supply lines for leaks and repairing if required. I		
f) Eliminate any unnecessary steps in providing water to users. I		
2.2 Purification		
a) Match the quality of water to intended use to minimize purification costs.		
1) Use grey water for toilet flushing and irrigation. F		
2) Catch and store rain water for irrigation. H		
3) Use recycled waste water. F		
4) Reuse once used water for a secondary use. F		
5) Use raw water if possible. F		
b) Improve the purification process efficiency measuring the present efficiency against design. I		

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
c) Improve pump efficiencies. I		
2.3 Collection		
a) Minimize inflow gains to collection lines by repairing leaks. I		
b) Consider separating different "waste" water flows to minimize the overall processing cost:		
1) Install dual plumbing for grey water and black water. F		
2) Direct "non-consumptive" use flows directly back to watershed. F		
3) Separate storm drains and special process drains from sanitary drains. F		
4) Consider direct use of "once used" water for a second use. F		
c) Consider reducing or eliminating collection by:		
1) Directing grey water for irrigation. F		
2) Installing toilet systems that use little or no water (See Toilets). F		
d) If a new collection system is under consideration, consider alternative collection systems such as pressure or vacuum sewers, using energy conservation as a criterion. F		Goodbye, pp. 34-36

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
2.4 Waste Water Treatment and Disposal		
a) Septic systems		
1) Don't cement or pave over the drain field. I		Septic, p. 61
2) Be certain to put only small amounts of soaps, detergents, bleaches and drain cleaners into the system. Large quantities can destroy the bacterial population that effects the clean-up of waste water. I		Septic, p. 59
3) Divert any rain water runoff away from the drain field. I		Septic, p. 61
4) Provide a separate drain for waste brines from household water softeners since they result in slow clogging. I		
5) Be wary of any products that claim to "clean" septic tanks or drain fields. They may cause more damage than good. (hydrogen peroxide injection into the drain field has had positive results.) I		Septic, p. 30
6) Don't put any items into the toilets other than human waste. (For example, don't flush cigarette butts, paper towels, sanitary napkins, or disposable diapers down the toilet.) I		Septic, p. 30
7) Provide for regular maintenance of your system. (This includes yearly inspection for proper operation, fixing of leaks or by-passes, and pumping of solids or scum.) I		Septic, pp. 59-61
8) Consider mounding or alternating the soil absorption systems. (T		Septic, p. 36

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
9) Consider alternative soil absorption location. F		
10) Consider a dosing system and distribution system with possibility of using pressure line feed. (T) F		*Septic*, p. 43
11) Consider soil field rejuvenation by EPA-recognized methods (such as injection of hydrogen peroxide). F (T)		
12) Consider lowering ground water table. (T)	F	*Septic*, p. 58
13) Consider modification of soil characteristics by physical methods such as mixing sand with existing soil. (T) F		*Septic*, pp. 41-43
b) Conventional sewage treatment plants (Department operated)		
*1) Assure that operators are fully skilled and perform required maintenance on equipment and systems.	I	
2) Reduce (increase) quality of effluent to the minimum required to optimize efficient use of energy and eliminate unnecessary process steps. I		
3) Compute efficiency of processors, pumps and other mechanical equipment and compare to expected efficiencies, improving where possible. I		
4) Consider renewable energy sources for operation of processing equipment to improve energy use efficiency. F		
c) Alternative on-site waste water treatment methods.		
1) Consider installing anaerobic biological treatment units such as single-compartment septic tank, compartmentalized septic tank, Imhoff tank, etc. (T) F		*Septic*, pp. 7-10, 15, 17-18

WORKSHEET I

WATER CONSERVATION

Measures	Current Status	Technical References
2) Consider installing aerobic biological treatment units operated on batch or continuous mode. Units with different aeration time, mixing pattern and sludge well circulation methods should be considered. (T) F		Septic, pp. 10-12
3) Consider combinations of anaerobic and aerobic units with various sequencing of unit treatment processes such as: (T) a. Anaerobic - anaerobic F b. Anaerobic - aerobic F c. Aerobic - anaerobic F d. Possible other combinations for enhancement of treatment performance. F		
4) Treat grey water by lagoon methods. (T) F		Treatment, pp. 25-26
5) Consider physical-chemical treatment methods such as liquid-solid separation by plain sedimentation or by coagulation sedimentation. (T) F		Treatment, pp. 22, 41
6) Consider using natural processes, including solar radiation, aquaculture, and natural aeration over a longer period of time as a disinfection method. (See On-Site Gen. Vol. II, Biomass section) (T) F		[illegible], pp. 185-187

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Measures	Current Status	Technical References
d) On-site waste water disposal methods.		
1) Consider using a conventional septic soil absorption system and its variations, such as a seepage pit or seepage trench. (T) F		Septic, p. 38
2) Consider sand filtration of septic or aerobic effluent with or without chemical aids prior to surface discharge or land application. (T) F		Treatment, p. 42
3) Consider sand filtration of septic or aerobic effluent with or without chemical aids prior to sub-surface discharge. (T) F		Treatment, p. 42
4) Consider total evapotranspiration with or without manual assistance of evapotranspiration potential. (T) F		Goodbye, pp. 179-182
5) Consider evapotranspiration system with infiltration/percolation allowance. (T) F		Goodbye, pp. 179-182
6) Consider an integrated greenhouse aquaculture system to provide food or fuel crop. (T) F		Goodbye, pp. 185-187
e) Waste residual handling and management methods:		
1) Pump and transport solids to regional facilities for disposal with maximum recovery of nutrients, such as landfill, composting and lagooning. F		Treatment, pp. 31-50
2) Consider on-site and off-site land application of solids as soil conditioners or fertilizer. F		Goodbye, p. 26
3) Consider biogas generation or other processes to generate energy while providing for suitable disposal. (T)(See On-Site Generation, Vol. II, Biomass.) F		

Worksheet II: Measures Evaluation

Measures	Potential Benefits	Action Required for Implementation	Barriers to Implementation	First Decision Point
Install water volume reducers in toilets	• Save 187,500 gals. of water annually • More water available to support trees and vegetation • Good example set for the public	• Buy reducers	• Possible visitor resistance to reduced water level in toilets	Go on

Worksheet II: Measures Evaluation (Part II)

Cost	Savings ($ and BTUs)	Payback Period	Training Needs	Motivation Problems and Incentives
$23 - fixtures $60 - installation $82 total	$46/yr. 4,500 x 10^{o} BTU	1.8/yrs.	None	• Put signs in rest rooms informing visitors of water and energy savings

WATER CONSERVATION

REFERENCES

1. Based on information from *Residential Water Conservation* by Murray Milne and *Goodbye to the Flush Toilet*, edited by Carol Hupping Stoner.

2. "Saving Water in the Home: 2. When You Take a Shower," *Consumer Reports*. May, 1978, pp. 300-302.

3. *Ibid*.

4. Milne, Murray, *Residential Water Conservation*. Davis, CA: California Water Resources Center, University of California, Report #35, March 1976, p. 282.

5. Springer, George S. and Gene E. Smith, *The Energy-Saving Guidebook*. Westport, CT: Technomic Publishing Co., Inc., p. 47.

WATER CONSERVATION

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A Guide to Energy Savings for the Orchard Grower. Washington, DC: U.S. Department of Agriculture, June 1977, 49 pp.

Milne, Murray Residential Water Conservation. Davis, CA: California Water Resources Center, University of California/Davis, Report #35, C. 1976. 469 pp.

Stoner, Carol Hupping (ed.), Goodbye to the Flush Toilet. Emmaus, PA: Rodale Press, Inc., C. 1977, 285 pp.

Treatment and Disposal Alternatives for Domestic Sewage Management. Washington, DC: The U.S. Department of Housing and Urban Development, 1978. G.P.O.#023-000-00445-3.

Warshall, Peter, Septic Tank Practices. Bolinas, CA: Mesa Press, C. 1976.

*CORE SOURCES (Buildings)

Guidelines for Saving Energy in Existing Buildings (ECM2). Washington, DC: Federal Energy Administration, 1975. (ECM-2)

*CORE SOURCES (On-Site Generation)

On-Site Generation. Arlington, VA: National Recreation and Park Assoc., with Earth Metabolic Design, New Haven, CT., 1978. (OSG)

Secondary Sources

A Customer Handbook on Water Savings and Waste Water Reduction. Hyattsville, MD: The Washington Suburban Sanitary Commission, May 1976.

Konen, Thomas P., Arthur Lesser, Richard J. Orend, James P. Van Hook, Water Related Energy Conservation. Hoboken, NJ: Stevens Institute of Technology, Davidson Laboratory, 1977.

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*Core books from other sections of the Planning Guide.

WATER CONSERVATION

ABSTRACTS

Core Sources

A Guide to Energy Savings for the Orchard Grower, Washington, DC: U.S. Department of Agriculture, June 1977, 49 pp.

This guidebook contains suggestions to help farmers use energy more prudently in the future. Topics covered include frost protection, fertilization, pesticide application, field operations (tillage, pruning, etc.), irrigation, and harvest. Of particular interest is the section that deals with irrigation. Methods for reducing energy consumption in all the usual irrigation systems are suggested, and examples showing how each method can save energy and money are provided.

Residential Water Conservation, Murray Milne, Reort #35, California Water Resources Center, University of California/Davis, C. 1976. 469 pp.

As the title suggests, residential water conservation (both indoors and outdoors) is the focal point of the book. A history of water use, energy consumption patterns, and the hydrologic cycle serve as background for this text. Economic aspects of water conservation suggest ways in which pricing mechanisms affect water consumption. The heart of the book is Chapter 6: Technological Alternatives. This chapter contains a review of commercially available water-using fixtures and systems for: (1) toilets, (2) bathing and personal hygiene, (3) drinking, cooking, and washing, (4) water and sewage systems, and (5) outdoor uses. (Water conservation and not energy conservation is the primary goal in introducing these systems, although energy conservation is realized using many of these systems.) The final chapter offers four scenarios that outline measures a homeowner can take to conserve water.

Some cost data is provided but a consistent way of decision-making is not worked out. It is a non-technical well written study that would be of interest to the general public, particularly the homeowner, architect, or public official concerned with water supply and use.

Goodbye to the Flush Toilet, Carol Hupping Stoner (ed.) Emmaus, Pa.: Rodale Press, Inc., C. 1977, 285 pp.

This book examines alternatives to the flush toilet, such as vacuum and flush toilets that either use no water at all or else use only about one quart of water with each flush. It looks at the potential of the self-contained chemical and incinerating toilets, and at aerobic tanks designed to replace septic tanks, at pressure sewers, at costly gravity sewers, and at total household water recycling systems, considering energy costs with water consumption and conservation. The primary focus is on composting privies and toilets. Descriptive, non-technical information useful to the average homeowner or waste manager is provided. Excellent illustrations.

Many of the advantages and disadvantages, costs, and size of commercially available composting toilets are compared. A chapter on greywater systems describes water treatment and suggests ways it can be reused.

Treatment and Disposal Alternatives for Domestic Sewage Management. Washington, DC: The U.S. Department of Housing and Urban Development, 1978, G.P.O.#023-000-00445-3.

This report provides a review of the treatment and disposal techniques available for domestic sewage management.

The basic characteristics and volume generation data for domestic sewage are discussed. Subsequent sections describe the mechanics of conventional primary, secondary, and tertiary sewage treatment processes. Discussion and analysis of ultimate disposal alternatives are provided with emphasis on disposal techniques, effluent qualities and treatment required, and typical regulations associated with each disposal method. Finally, the overall capabilities of sewage treatment process/disposal alternatives are summarized in regard to pollutant removals, operational requirements, and reliability.

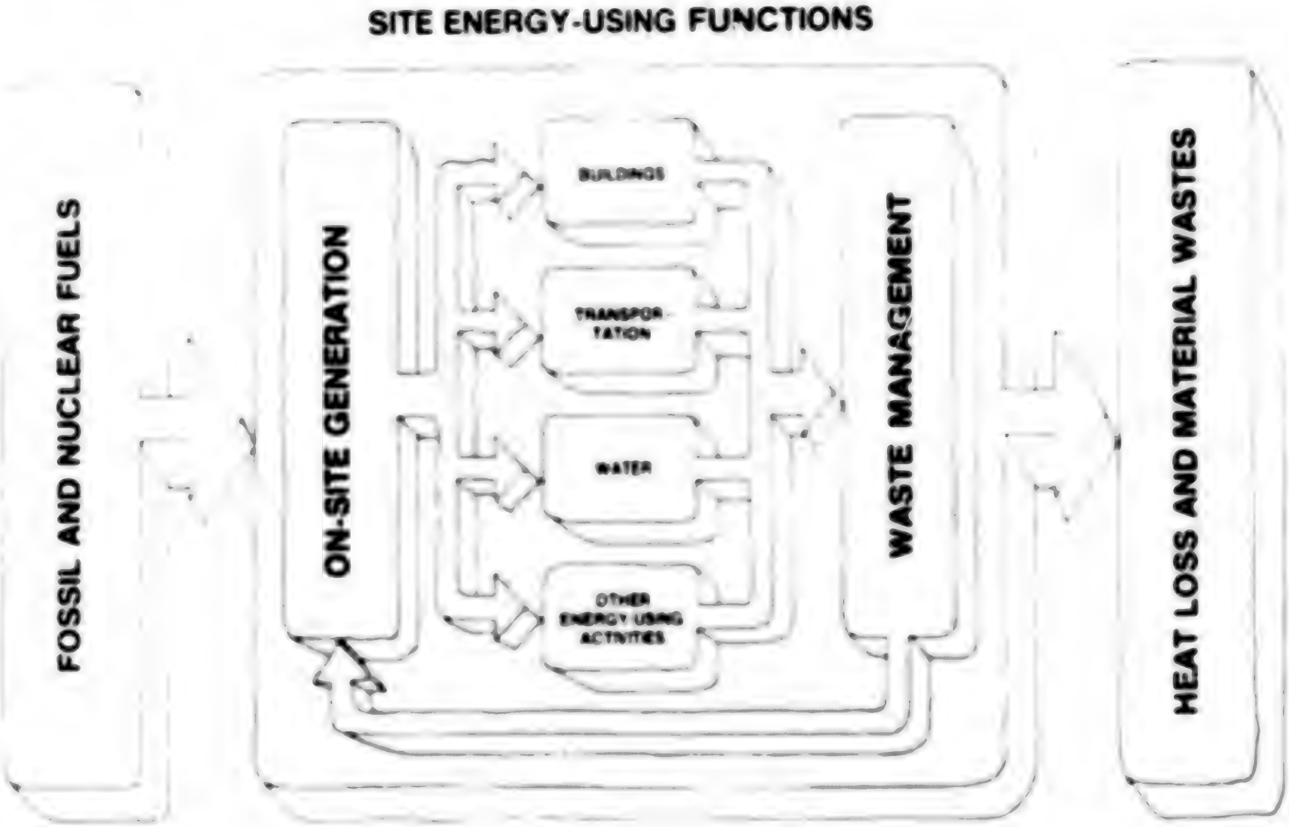
Septic Tank Practices. Peter Warshall. Bolinas, CA: Mesa Press, C. 1976.

This book provides an excellent description of small-scale on-site sewage treatment methods. Careful consideration is given to local disposal methods in which nutrients can be returned naturally to the surroundings, where they can be used by plants.

Information useful to operations and maintenance staff is provided on septic tank and drainfield design, construction, care, and maintenance. By anticipating ecological problems and analyzing site conditions at the design stage, some modification of site conditions and adaptation of the system to site conditions can improve the operation and maintenance of the system when it is in place.

Environmental Awareness Programs

VOLUME I
BOOK 6



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This section on Environmental Awareness Programs is part of a two volume *Planning Guide* designed to help you formulate an overall site-specific Energy Conservation Management Plan. It provides you with a list of resources to serve as the focus for interpretive programs at your site which explain how energy can be conserved, as well as instructions for designing the programs.

ENVIRONMENTAL AWARENESS

INTERPRETIVE RESOURCES: OPPORTUNITIES FOR ENVIRONMENTAL AWARENESS PROGRAMS

Interpretation of energy themes for the public must be an integral part of any site's energy conservation program. Because all processes involve energy transfer, almost anything can be the subject of an environmental awareness program on energy, once you understand the basic principles of energy transfer and see them at work in natural and managed systems. The only limits on coming up with new ideas for programs are how much good information on the subject you have at hand, and your own creativity in using it. However, in putting together the Planning Guide, we've taken an extra step and come up with a list of interpretive resources that can be used as a starting point in developing programs with energy themes. There are several important reasons for this:

- The list of resources helps in creating programs, by identifying potential subjects or themes.
- Energy aspects of different resources are discussed in reference materials that are keyed to the list.
- The list helps to organize programs, so that a variety of subjects and methods can be created and delivered.
- The list makes site-specific planning easier, since planners need not consider resources that don't exist at the site, and can focus instead on those that do.

How the Resources Are Organized

Interpretive resources have been organized in outline form under two major headings: "Natural Systems" and "Managed Systems." These are further subdivided as follows:

The resources under "Natural Systems" are:

- Ecosystems (Habitat types)
- Animals
- Plants
- Geologic Features
- Climate
- Astronomical Features.

Greater detail is given in each of these categories. For instance, under "Plants," there are headings for trees, shrubs, herbs and grasses, fungi, and algae.

Under "Managed Systems," the broad range of man's activities has been divided into several groupings. These are:

- Land and Water Management
- Plant and Animal Management
- People Management

The section on "People Management" is extensive and is further divided into "Site Administration Impact" and "Cultural Impact." References dealing with On-Site Energy Sources, are included as a subheading of "Site Administration Impact." Why? Use of a new energy source like hydropower will depend on administrative decisions as to how the site should be managed.

The outline is a framework from which to start. If you work at a large natural area in the West, and the interpretive programming at your site emphasizes mountain ecology, the outline can help you find references that deal with energy aspects of mountain ecosystems. If, on the other hand, you're looking for some variety in your programming, you might choose a topic under "Site Administration Impact," and interpret Resource Protection from an energy perspective. Once energy themes are familiar to you, new ways of applying them will occur to you easily. As we said above, the opportunities for coming up with environmental awareness programs on energy are limited only by the amount of good information at your disposal and by your own creativity.

USING THE REFERENCE MATERIALS

How the Reference Materials Can Help

As you work through the "Planning Process" section which follows, you'll probably find yourself needing more information on energy that fits in with your new ideas or activities. The reference materials on Environmental Awareness Programs are intended to provide some of that information, but we encourage you to keep on looking! We've assembled a good group of references, but the references for other sections of the Planning Guide and your local library are certain to have valuable information that couldn't be included with this package.

As you develop program ideas, there are several kinds of situations where the references will be useful. First, if you feel you'd like a broader understanding of energy in natural and managed systems, you'll want a general reference to read through for background. The first two books in this collection, the Energy Manual for Parks and Energy Basis for Man and Nature are intended to provide this broad understanding. Second, as you come to certain columns on the Worksheets - "Interpretive Method" or "Resources Needed for this Activity," for instance - you may draw a blank, especially if you haven't had any experience with this new field, and you're trying to come up with ideas. The Energy Workbook for Parks has a great many activity ideas and lists the resources you'd need to present them. The Energy Workbook is not a comprehensive source, and you'll soon look beyond it as you use different methods and address different target audiences. However, some of the suggestions in its pages will help to get the ball rolling.

Lastly, as you build your program, don't neglect the other sections of the Planning Guide. Valuable information is presented in each, from Buildings to On-Site Generation. If plans have been made to modify some of the buildings at your refuge or hatchery to make them more energy efficient, you may want to include some mention of it: a check with the reference materials for Buildings will help you understand the technical changes that are being made.

Examples

To help you see what we mean, we've included an example of how the references can be used to help you complete the planning exercise and create new programs using energy themes.

Perhaps you work on a refuge which manages a prairie ecosystem. Looking under "Natural Systems," you come to "Prairie and Meadow" Ecosystems. There you find references which help explain energy flows in prairie systems. For a broad picture, you might go first to Odum's discussion of energy flow in ecosystems. Then, if you wanted to cover animal populations, scientific articles such as "Thermodynamic Equilibria of Animals with Environment" are listed. These publications give you specific information regarding energy and natural systems. When you have a good start on program ideas, you might decide to include a study of prairie rodents in a direct instruction activity aimed at fifth grade students. They could do an inventory of a prairie ecosystem, to include all natural and man-generated components. Once they've made the inventory, the students could make a diagram of energy flows. Then, as an exercise, they could be asked to vary different components, such as available forage, drought, or visitors who feed junk food to chipmunks. The references in the package will help, but they are not always specific. Additional information from the site library or other local sources will be essential, once your program is outlined.

PLANNING PROCESS

As with other divisions of the Planning Guide, we have included a "Planning Process" section here to help you put together a workable program based on the preceding information and your own resources. However, this particular planning section is unique in several respects. First, no conservation measures are listed here. Instead, Worksheets I, an outline of Interpretive Resources, is presented. These resources are not ranked according to priority as the conservation measures in other sections are. You need only select those resources which are applicable for your site. Each interpretive resource can be seen as an opportunity for communicating an energy message to visitors and staff. Second, Worksheets II, Measures Evaluation, for this section are different from those which appear elsewhere. They have been developed specifically to help you plan new environmental awareness programs. A sample of Worksheets II, which has been filled out for you is included after the list of resources. Third, those working on new programs dealing with energy are encouraged to contact personnel in other divisions who are developing energy conservation management plans. The exchange of ideas with fellow staff members can be particularly useful in developing varied and interesting programs. In addition, assistance from your Regional Coordinator may be available as you develop your interpretive program.

The following presents a three-step process that will enable you to use the materials provided for planning. These steps are:

Step 1. Familiarize yourself with the concepts of environmental awareness programs in the preceding pages.

If you have not already read these sections you should do so before continuing. They will help to give you an overview of the energy laws that affect all systems; they explain the organization of interpretive resources; and provide a guide and some examples of how to use reference materials in developing programs on energy themes.

Step 2. Identify interpretive resources.

Using the outline of interpretive resources, Worksheets I (see below) and your knowledge of existing resources, themes, and programs at your site, select those that might be used as the subject of an interpretive message on energy. Use reference materials to increase your understanding of the energy aspects of the resources you've chosen.

Step 3. Complete Worksheets II.

Use Worksheets II for Environmental Awareness Programs to plan activities, presentations, and other new program ideas. Work from the left-hand side of the sheets to the right, adding new information as you go from column to column. This step can be performed by an individual, but often is faster and livelier if done in a small group. An explanation of the columns, and what goes in each, is given below:

Interpretive Resource

Fill out this column by selecting an interpretive resource from the outline or choosing one of your own. Anything that can be interpreted or that can serve as the subject of an environmental education program is potentially an interpretive resource, whether it is a famous landmark, an ecosystem, or a legend.

Target Audience

In this space, note the visitors who might be involved with the resource, when interpretation is possible. Consider their similarities and differences. Where possible, indicate age level, educational background, and the likelihood that they have previous knowledge of the subject. Consider what is likely to affect the audience you have profiled here.

Subject of Energy Message

In this column, record specific information and ideas on the energy theme that will be conveyed through interpretation of the resource. Background information from the technical references can be written here.

Interpretive Method

This is the place to show what activity or medium you choose to convey the message. Below, you'll find a list of interpretive methods, together with an example of an appropriate use of each one:

- Verbal Message: Explaining an energy conservation measure to a visitor, who asks why a vestibule is being installed at the front door of the visitor center.
- Interpretive Talk: Giving a campfire program and a slide show on energy flows in natural and managed systems.
- Self-Guided Tour: A nature trail with a pamphlet or signs explaining how energy moves through the ecosystem.
- Signs and Posters: A sign on a solar collector, explaining the mechanics of the system and its impact on fuel use at the site. A poster displayed in an interpretive center that traces the history of the use of wind power.
- Displays: Showing the operating principles of hydropower systems, with a waterwheel or small hydroelectric generator. Unmanned slide shows and audio messages could also be used here.

- Demonstrations: Building a homemade solar collector with available materials. Including an energy message with demonstrations of cooling on a wood stove or campfire.

- Literature: Researching and writing up energy ideas for the area, using background information and local sources, including energy messages in publications developed by refuge or hatchery staff and cooperating associations, such as activity schedules and programs.

- Newsletters: Sharing new ideas on activities or energy-saving measures in Departmental newsletters.

- Special Events: Holiday programs, festivals, or other unique events may be opportune times for special activities or projects on energy.

- Direct Instruction: Adding energy ideas to existing environmental education materials, or developing new ones.

How Method Will Convey Energy Message

In this column, the method and the message come together. Show how the chosen method or interpretive technique can get the message across to the target audience.

Potential Barriers

The new program might, in some way, conflict with policy, cause a safety hazard, endanger the resource, or produce undesirable effects on the visitor or the public in general. If it won't be an interesting program for interpreters to deliver, lack of staff motivation may also be a barrier.

Anticipated Goals/Benefits

This space is reserved for a statement of the objectives met by conveying the message. It should show the value or positive results which can be anticipated from implementing each new program. Note the impact on visitors, potential community goodwill, resulting energy savings, improvements in staff morale, or movement toward achievement of management goals.

Check Point

At this point, decide whether to stop or go on. Does the idea deserve further consideration? Compare expected benefits with the barriers to implementation. When barriers are large and benefits are minor, you'll probably decide to stop. Even when expected benefits are significant, stiff barriers may force a halt in further planning. Another option, between "stop" and "go on," is to call for a feasibility study. If a major commitment on the part of the site is called for, more study is probably warranted.

Resources Needed

Most interpretive methods call for resources of some kind -- audio-visual equipment, firewood, or materials for homemade props and displays, to name a few. Some are readily available, others are hard to find or expensive to acquire. Identify what you'll need in this column.

Estimated Cost

Estimate the cost of any resource materials identified in the previous column. Give a separate estimate of the number of hours required to prepare and present the activity. This should reflect not only the time of the interpretive staff, but also that of maintenance personnel and others who might be called on to prepare materials.

Estimates of dollars and hours should be shown in this space, with whatever explanation is needed. It should be remembered that funding for interpretive programs does not necessarily have to come from site operating budgets. You should investigate the availability of Interpretation and Recreation funds.

Potential Activity Hours

An estimate of the number of activity hours generated by the new program can be calculated by using a simple formula,

T x N x P = Potential Activity Hours

where (T) is the amount of time devoted to the energy message, (N) is the number of times the message is given each year, and (P) is the number of people who will participate. Activity hours generated by signs can be figured by

T x N = Potential Activity Hours

where (T) is the average time taken to read the sign, and (N) is the estimated number of people who will see the sign in a year.

Evaluation Method

This last column should show some method for determining whether the program is achieving anticipated goals. The techniques employed here can be fairly subtle. For example, the goal of an activity might be to show how wasting resources such as trees means wasting energy, and the message is written up in a brochure. One evaluation technique would be to observe the use of the brochures. Do people take them? Do they throw them on the ground or put them in a pocket to read later? If you prepare an oral presentation, you can build in evaluation questions to ask participants. Their answers will indicate whether they've understood what you've been saying. Listening for the types of questions that visitors ask at the end of a presentation can also help in evaluation.

After you have compiled a list of potential conservation measures for this section and have completed your planning worksheets, you should review the material in the Introduction which explains how to pull all of your measures together into a comprehensive Energy Conservation Management Plan.

REMEMBER: The measures you are considering for environmental awareness are meant to be a part of your total plan.

WORKSHEET I
POTENTIAL
ENVIRONMENTAL AWARENESS CONSERVATION MEASURES

WORKSHEET I

ENVIRONMENTAL AWARENESS PROGRAMS

Interpretive Resource	Current Status	Technical Reference **
I. NATURAL SYSTEMS		
A. Ecosystems		Energy Basis, p. 93-114; Energy Manual, Ch. 2 & 8
1. Prairie and Meadow		Bioenergetics, p. 545; Pop. Energy Flow, p. 88-96
2. Forest		Energy Basis, p. 69, 107-111, 135-137
3. Marine		Energy Basis, p. 142-143, 109-111, 205-206
4. Desert		Development, p. 21-22; Energy vs. Archeology, p. 14-15; Thermodynamic, p. 234-236; 239-242
5. Mountain		Energy Basis, p. 123-126
6. River and Stream		Energy Basis, p. 100-105
7. Lake and Pond		Energy Basis, p. 142-143, 109-111
8. Cave		Development, p. 11-14, 66-68
9. Marsh		
10. Beach		Energy Basis, p. 113, 175; Energy Ideas, p. 6-7
11. Arctic		Heat Regulation, p. 237-258; Energy Basis, p. 139
12. Other		
B. Animals		Energy Basis, p. 99-102, 109-113; Thermodynamic, p. 227-244
1. Mammals		Heat Regulation, p. 237-258; Bioenergetics, p. 537-548
2. Birds		Thermodynamic, p. 227-233, 236-238; Development, p. 96a & b

** These references are part of a core library which should accompany these energy conservation/management planning materials.

WORKSHEET I

ENVIRONMENTAL AWARENESS PROGRAMS

Interpretive Resource	Current Status	Technical Reference
3. Reptiles		**Thermodynamic**, p. 235-236
4. Amphibians		
5. Fish		**Energy Basis**, p. 72-73, 205-207
6. Invertebrates (including insects)		
C. Plants		
1. Trees		**Energy Basis**, p. 103-106
2. Shrubs		
3. Herbs		
4. Fungus, lichens, algae, mosses		
D. Geologic Features		**Energy Basis** 123-129
1. Plate Tectonics		**Energy Basis**, 123-126
2. Sedimentary Rock Formation		**Energy Basis**, p. 123-126, 129
3. Igneous Rock Formation		**Energy Basis**, p. 129
4. Metamorphic Rock		
5. Diastrophism		
6. Erosion		**Energy Basis**, p. 123-127
7. Hydrological Features (waterfalls, sand bars, cutbanks)		**Energy Basis**, p. 120-121
8. Geothermal Features		**Energy Basis**, p. 125, 187-188; **Energy Manual**, Ch. 5, p. 12-13
9. Glacial Features		
10. Volcanic Features		**Energy Basis**, p. 126-127
11. Topography		

WORKSHEET I

ENVIRONMENTAL AWARENESS PROGRAMS

Interpretive Resource	Current Status	Technical Reference
E. Climate		
1. Water Cycle		Energy Basis, p. 29, 44-45, 120-121
2. Wind Cycle		Energy Basis, p. 118-123, 172-175
3. Pressure Systems		Energy Basis, p. 118-121
4. Extremes (tornadoes, hurricanes, floods, droughts, etc.)		
5. Available solar energy		
F. Astronomic Features		
1. Sun		Children, p. 6-15
2. Stars (constellations nova, nebula, etc.)		
3. Planets		
4. Moons		Energy Workbook, p. 27
5. Galaxies		
II. MANAGED SYSTEMS		
A. Land and Water Management		
1. Urban Areas		
2. Town and Village		
3. Rural Areas		Energy Workbook, p. 72
4. Wilderness		
5. Recreation Areas (picnic areas, campgrounds, golf courses, etc.)		
6. Environmental Study Areas		
7. Research Areas		

WORKSHEET I

ENVIRONMENTAL AWARENESS PROGRAMS

Interpretive Resource	Current Status	Technical Reference
8. Boundaries (man's impact on energy flow by designating linear boundaries)		
9. Dams		Energy Manual, p. C-30 to C-31
10. Reservoirs		
11. Ponds		
12 Waterways (rivers, streams, canals)		
B. Plant and Animal Management		
1. Controlled Animal Areas (especially those areas set aside for animals which cannot be easily confined and protected, such as buffalo)		
2. Habitat Areas (especially those areas set aside for animals which cannot be easily confined, such as birds)		
3. Raceways		
4. Parks		Development, p. 1-100; Energy vs. Archeology, p. 14&15; Energy Workbook, p. 22, 27, 89
5. Fish Production/Distribution		
6. Agriculture (including livestock and silviculture)		Energy Manual, p. 4-3 to 4-4; Energy Workbook, p. 72
7. Endangered Species		
C. People Management		
1. Site Administration Impact		
a. Transportation		
b. Visitor Flow		

WORKSHEET I

ENVIRONMENTAL AWARENESS PROGRAMS

Interpretive Resource	Current Status	Technical Reference
c. Buildings		
d. Recreation (hiking, camping, skiing, etc.)		
e. Interpretation		
f. Concessions		
g. Resource Protection		
h. Law Enforcement		
i. Regulations/Policy		
j. Waste Management		
k. Planning		
l. Energy Sources On-Site		Producing Power, p. 13-15, 61-63, 103-104, 191-193; On-Site Generation, Vol. III
2. Cultural Impact		
a. Social Systems (mutual relations of people)		Energy vs. Archeology, p. 14-15
b. Communication		
c. Political Systems		
d. Religion		
e. Ritual/Tradition		
f. Economic Systems		Energy Manual, p. 4-1 to 4-6; Energy Basis, p. 199-203
g. Educational Systems		
h. Art		
i. Shelters (living and occupational)		
j. Transportation		Energy Manual, p. 6-11 to 6-19; Energy vs. Archeology, p. 14

WORKSHEET I

ENVIRONMENTAL AWARENESS PROGRAMS

Interpretive Resource	Current Status	Technical Reference
k. Food Production and Preparation		Producing Your Own Power, p. 103-135
l. Military Systems		Energy Basis, p. 209
m. Artifacts (archeological artifacts, documents, etc.)		Energy vs. Archeology, p. 14-15

Worksheet II: Measures Evaluation

Interpretive Resource	Target Audience	Subject of Energy Message	Interpretive Method	How Interpretive Method Will Convey Energy Message
Historical building (heating system - wood stoves)	Aggregates: campers, tour groups, hikers, families Age level: all Ed. level: all Impact: international Previous knowledge: None	Comparing modern with early American heating	Demonstration of wood stove during tour of historical home	Point out that early settlers knew what types of wood provided the best heat for use in the stove. Several types of local trees can be shown and their relative density/energy explained
Energy sources on site - wind	Aggregates: families, hikers Age level: all but the elderly and the very young Ed. level: all Impact: local to national Previous knowledge: none	Explain how wind can supplement or replace conventional energy	Demonstration of existing windmill as source of energy generation on trail walk	Show electrical output by attaching a volt meter and light bulb to an electric generator associated with the windmill. Visitors are instructed how to engage the device and a sign will read: "The same wind that cools us on a hot day, or that sings to us from the tops of fir trees, can bring light to darkness. Harnessing its power is transforming its gift."
Controlled animal areas	Aggregates: families, hunters, fishermen, school and conservation groups Age level: all Ed. level: all Impact: local Previous knowledge: some	Energy (food) as limiting factor in population	Wildlife brochures available in Visitor Center to explain management problems of large mammals.	Energy in the form of forage - as a limiting factor of the number of buffalo possible on a refuge

Worksheet II: Measures Evaluation (Part II)

		Implementation Issues					
Potential Barriers	What is the Goal/Benefit of this Activity	Decision Point	Resources Needed for this Activity (Materials and Staff Support)	Estimated Cost ($ & Hrs)	Training Needs	Potential Activity Hrs/Yr	Evaluation Method
- Air pollution - Visitors may get the wrong impression of park policy re conservation - Inappropriate ventilation - Can't use park wood	- Familiarize visitors with the use of wood burning stoves - Introduce types of native trees by relating their heating efficiency	Stop					
- Visitor safety - Cost	- Awaken visitor awareness of alternative energy potential - Interpret existing piece of machinery, addingto its importance	Study					
- Visitor disinterest - Negative attitudes re generation of more paper	- Explain import of energy availability as determining factor in populations - Public acceptance of management policy that restricts growth of herds	Go on	Help in designing and printing the brochures	5¢/brochure = $25 for 25,000	None	3,500 hrs/yr	Small, informal survey, based on direct observation of how many brochures are taken and read, assuming that each brochure reaches an audience of 4 people. Extrapolate sample results to remaining population

ENVIRONMENTAL AWARENESS

REFERENCES

Center for Wetlands, University of Florida, and Bureau of Comprehensive Planning, Division of State Planning, Florida Department of Administration. *South Florida: Seeking a Balance of Man and Nature.* Gainesville, FL: University of Florida, (no date), p. 11.

ENVIRONMENTAL AWARENESS

BIBLIOGRAPHY

Core Sources

Energy Ideas, Arlington, VA: Energy Conservation Project, National Recreation and Park Association, No. 11, March 1978.

Johnson, D.R. and K.L. Groepper, "Bioenergetics of North Plains Rodents," *American Midland Naturalist*. 84:537-548, 1970.

Lewis, William J., "Development of the Energy Conservation Theme for Use in National Parks: Final Report to the Field Directorate," Washington, DC: National Park Service, 1976.

Matthews, Jean, "Energy vs. Archeology: What We May Never Learn from Chaco Canyon," *Courier*. Washington, DC: National Park Service, 1:14-15. 1977.

Odum, E.P., Clyde E. Connell and Leslie B. Davenport, "Population Energy Flow of Three Primary Consumer Components of Oil-Field Ecosystems," *Ecology*, 43:88-96, 1962.

Odum, Howard T, and Elizabeth C. Odum, *Energy Basis for Man and Nature*. New York, NY: McGraw-Hill Book Company, 1976.

Philbin, Janis, *Children of the Sun*. Sacramento, CA: Office of Environmental Education, N.W. Section, 1978.

Porter, Warren P. and David M. Gates, "Thermodynamic Equilibria of Animals with Environment," *Ecological Monographs*. 39:227-244, 1964.

Scholander, P.F., Vladimir Walters, Raymond Hock, F. Johnson, and L. Irving, "Heat Regulation in Some Arctic and Tropical Mammals and Birds," *The Biological Bulletin*. 99:237-258, Feb.-June, 1950.

Stephenson, Lee, *Energy Manual for Parks*. Arlington, VA: Park Project on Energy Interpretation, National Recreation and Park Association, 1976.

Stephenson, Lee and Nancy Strader, Energy Workbook for Parks. Arlington, VA: Park Project on Energy Interpretation, National Recreation and Park Association, (not in print), 1977.

Stoner, Carol Hupping (ed.), Producing Your Own Power. New York: Vintage Books, C. 1974.

Core Sources* (On-Site)

On-Site Generation. Arlington, VA: National Recreation and Park Association, 1978. (Prepared by Earth Metabolic Design, New Haven, CT along with the National Recreation and Park Association.) (On-Site)

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*Core books from other sections of the Planning Guide

Secondary Sources

Energy Education Materials Inventory, Booklets I-VI. Energy & Man's Environment, Portland Ore. 1976, prepared for Fed. Energy Admin.

Energy for Rural Development. Washington, DC: National Academy of Sciences, 1976.

Energy Primer. Menlo Park, CA: Portola Institute, Whole Earth Truck Store, 1974.

Miller, G.T. Jr., Living in the Environment: Concepts, Problems, and Alternatives. Belmont, CA: Wadsworth Pub. Co., Inc., 1975.

Odum, E.P., Fundamentals of Ecology, 3rd ed. Philadelphia, PA: W.B. Saunders Co., 1971

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ABSTRACTS

Core Sources

Energy Ideas, Arlington, VA: Energy Conservation Project, National Recreation and Park Assoc., No. 11, 1978.

A brief look at the status of wind energy producing systems, the benefits, and problems that exist. Three interpreters then explain how wind energy affects their parks, and how they have incorporated wind energy into their interpretive programs.

"Bioenergetics of North Plains Rodents," American Midland Naturalist, D.R. Johnson & K.L. Groepper. 84(2):537-548, 1970.

The study of bioenergetics is a difficult one due to the general lack of specific information. In this study, the relative metabolic rates and assimilation efficiencies are discussed, and correlations are made which show certain patterns of energy use. Measurements were taken at rest and with exercise. Although results in the study are limited, the use of rodents serves as a good example of the type of information necessary to understand the flow of energy through biological systems.

"Development of the Energy Conservation Theme for Use in National Parks," William J. Lewis, Final Report of the Field Directorate, National Park Service, 1976.

Dr. Lewis is a professor of communication at the University of Vermont, and an Oral Communication Specialist with the National Park Service. In 1975, Dr. Lewis was contracted to review existing efforts to include energy in interpretive programs and the potential to do more in the future. Dr. Lewis visited forty areas (primarily NPS) and inventoried what he saw as appropriate methods to incorporate energy interpretation. The report documents the visits, describing brainstorming sessions, ideas he came across, and critiquing activities and personnel. The introduction and summary are included to give examples of what can be done in a variety of settings. The process of brainstorming and determining what is appropriate as an energy interpretive resource at a site is well represented in Dr. Lewis' efforts.

"Energy vs. Archeology" What We May Never Learn From Chaco Canyon," Jean Matthews, Courier, National Park Service Newsletter, 1:14-15, 1977.

In true interpretive fashion, Jean Matthews sees the implications of energy availability on a primitive society which once inhabited Chaco Canyon National Monument. Then the author takes her theory one step further, to look at current plans for the area adjacent to the canyon which may become a modern-day boomtown. Although the information is specific to Chaco Canyon, the method for applying energy fundamentals to cultures is appropriate for other areas.

"Population Energy Flow of Three Primary Consumer Components of Old-Field Ecosystems," Ecology, E.P. Odum, C.E. Connell, & L.B. Davenport, V43:88-96, 1962.

This study determined the population energy flow of three major primary consumer groups living in the early stages of old-field succession. The three groups were: grasshoppers and crickets, Savannah sparrows, and old-field mice. Statements concerning the amount of energy used for production; amount of available energy required by the population; and food as a limiting factor in the populations, make the study helpful in determining the role of trophic levels and populations, make the study helpful in determining the role of trophic levels and populations in utilizing available energy. Tables in the study explain respiration rates, utilization of plants by herbivores and granivores, and methods for estimating population energy flow.

Energy Basis for Man and Nature, Howard T. Odum, and E.C. Odum, N.Y.: McGraw-Hill Book Co., 1976.

A thorough and concise explanation of the author's theory of integrating energy, environment, and economics based on a series of diagrams. An explanation of the diagram symbols and terminology is a necessary tool in working with this approach to energy systems and flow. Of particular interest to the interpreter is the section entitled, "Flows of Energy Build and Operate Systems" which includes the principles of energy and energy flow in ecological systems. Familiar topics treated with a new approach are: succession of species, food chains, mineral cycles, and diversity. The author expands these systems to illustrate human support systems and the controversial area of social change.

Children of the Sun, Janis Philbin, N.W. Office of the State Office of Environmental Education, Sacramento, CA, 1978.

The emphasis is on solar energy in this collection of information and activities for grades 5 - 12. Along with introduction to basic concepts and terminology, the book contains a wide range of activities suitable for direct instruction in an outdoor setting. Exercises cover plotting the sun using simple astronomical instruments; measuring heat storage capacity of diverse items; building simple solar cookers; and applying energy education to problems of society and communication. With minor changes, the activities can take on significance on a site-to-site basis.

"Thermodynamic Equilibria of Animals with Environment," Ecological Monographs, W.P. Porter and D.M. Gates, V39, 227-244, 1964.

A helpful overview of energy flow within an ecosystem and the energy budget, introduce this study which also includes a large amount of detailed graphs and equations. Regardless of your interest or disinterest in the technical detail, the concepts discussed are important to the understanding of energy and natural systems. Other specific topics covered in the study are: climate space, radiation absorption, energy exchange as related to body surface, and heat transfer within the animal. Specific animals covered in the study are desert iguana, masked shrew, zebra finch, Kentucky cardinal, sheep, pig, and jack rabbit.

"Heat Regulation in Some Arctic and Tropical Mammals and Birds," Biological Bulletin, P.F. Scholander, Raymond Hock, V. Walters, F. Johnson, & L. Irving, V99, pp 237-258, 1950.

A comparative study of the effects of temperature change on metabolic rate and body heat in animals from the cold and hot regions of the world. Included in the study were white fox, Eskimo dog, polar bear cubs, ground squirrels, lemmings, weasels, arctic gull, Canada jay, snow bunting, sloth, night monkey, marmoset, raccoon, coati, jungle rat, manakin, and night hawk. Comparisons of animals as to size as well as location, are helpful in understanding the basic heating and cooking mechanisms in animals that man has augmented with his stoves and air conditioners. The information is technical, but for those who aren't interested in figures, there are interesting items like, "Fur clothing and fur sleeping bags are usually not made from the heaviest winter fur, but rather from lighter autumn fur with less insulating value."

Energy Manual for Parks, Lee Stephenson, Arlington, Va: National Recreation and Park Assoc., 1976.

A document produced by the Park Project on Energy Interpretation, this manual is designed to give interpreters the basic information they need to include energy messages in their programs. The Laws of Thermodynamics and other theories of energy are presented with an emphasis on natural systems. Overviews include alternative energy sources, the energy situation in man's system, the potential and necessity for conservation, and a look at what's in store. The manual is full of a variety of charts and graphs, such as the carbon cycle, worldwide look at energy use per capita, comparative environmental impacts of energy options, and a simple solar heating system. Appendices list measurements and conversions, alternative energy forms, a bibliography, and additional resources.

Energy Workbook for Parks, Lee Stephenson and Nancy Strader, Arlington, VA: National Recreation and Park Assoc., 1977, (not in print).

Chapter titles include, "The Sun Does It," "What is Energy?," "Flow and Cycle," "Rules of the Game," "Eat at Sol's," and "Limits." In each chapter there is general background and scientific information combined with specific activities that have been tried by interpreters throughout the nation. Many of the activities represent first attempts at incorporating energy themes in the outdoor setting of parks. Perhaps the most useful way to approach this book is to see it as a stimulus for you to adapt particular ideas and information to your individual style and program. Activities range from subtle messages to entire presentations concerning energy. A list of information sources can be found in the back.

Producing Your Own Power, Carol Hupping Stoner (ed.), NY: Vintage Books, C. 1975.

A team of scientists, engineers, educators, and architects combined forces to produce this very readable test on alternative energy sources. Chapters include information on wind power, water power, wood burning, methane, and solar power. Short histories of the evolution of the technology are given in each area. Of particular use to interpreters are the instructions on developing small systems, such as a water wheel or windmill. Charts and graphs explain relative energy stored in different types of wood, airflow through a wood stove, power output by different wind generators, the parts to windmills, and other interesting areas. Although it would be difficult to develop an energy producing system using this book alone, the application of the technology to low-key systems is very helpful in making the system explainable to the casual park or refuge visitor.

End

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